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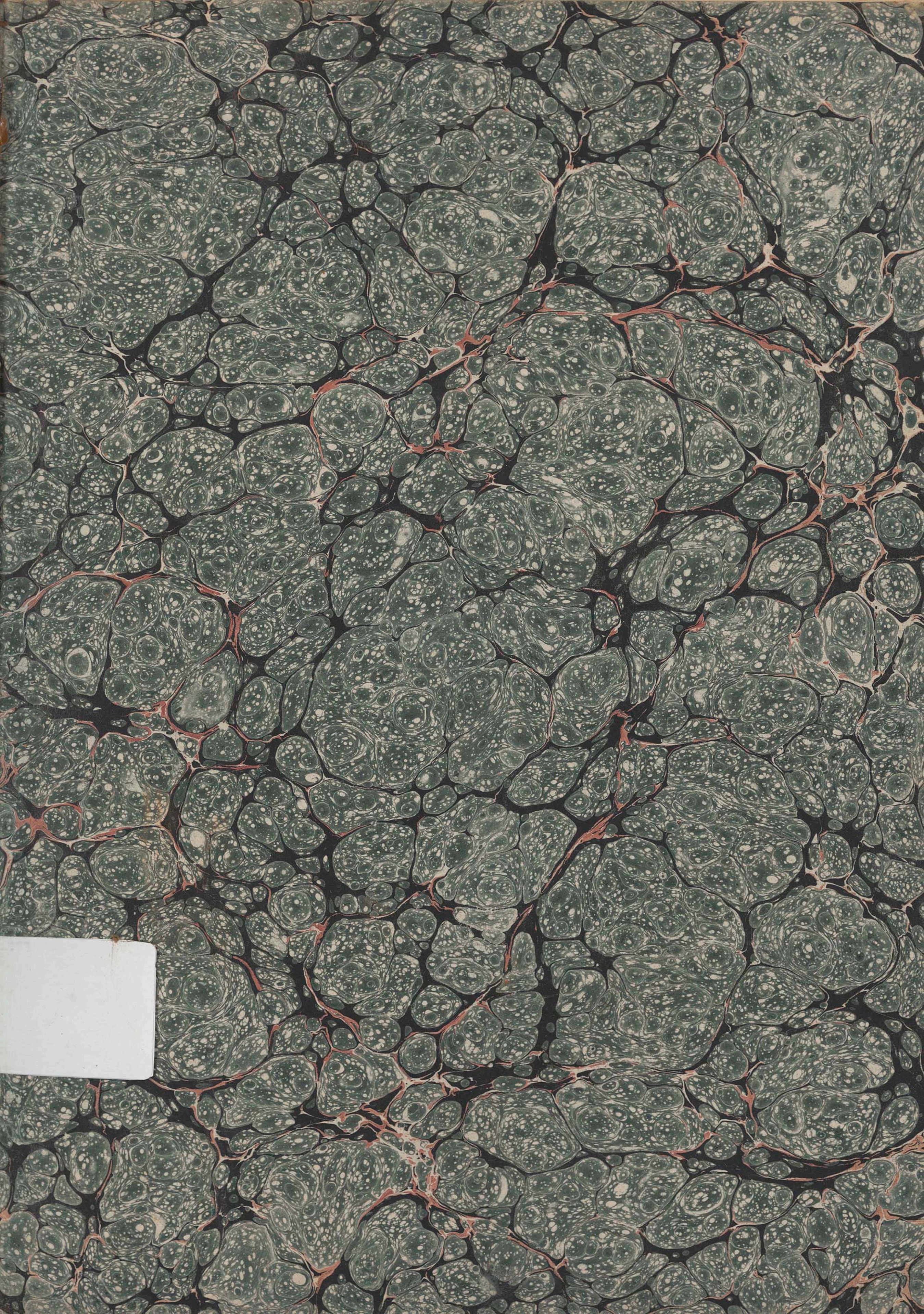
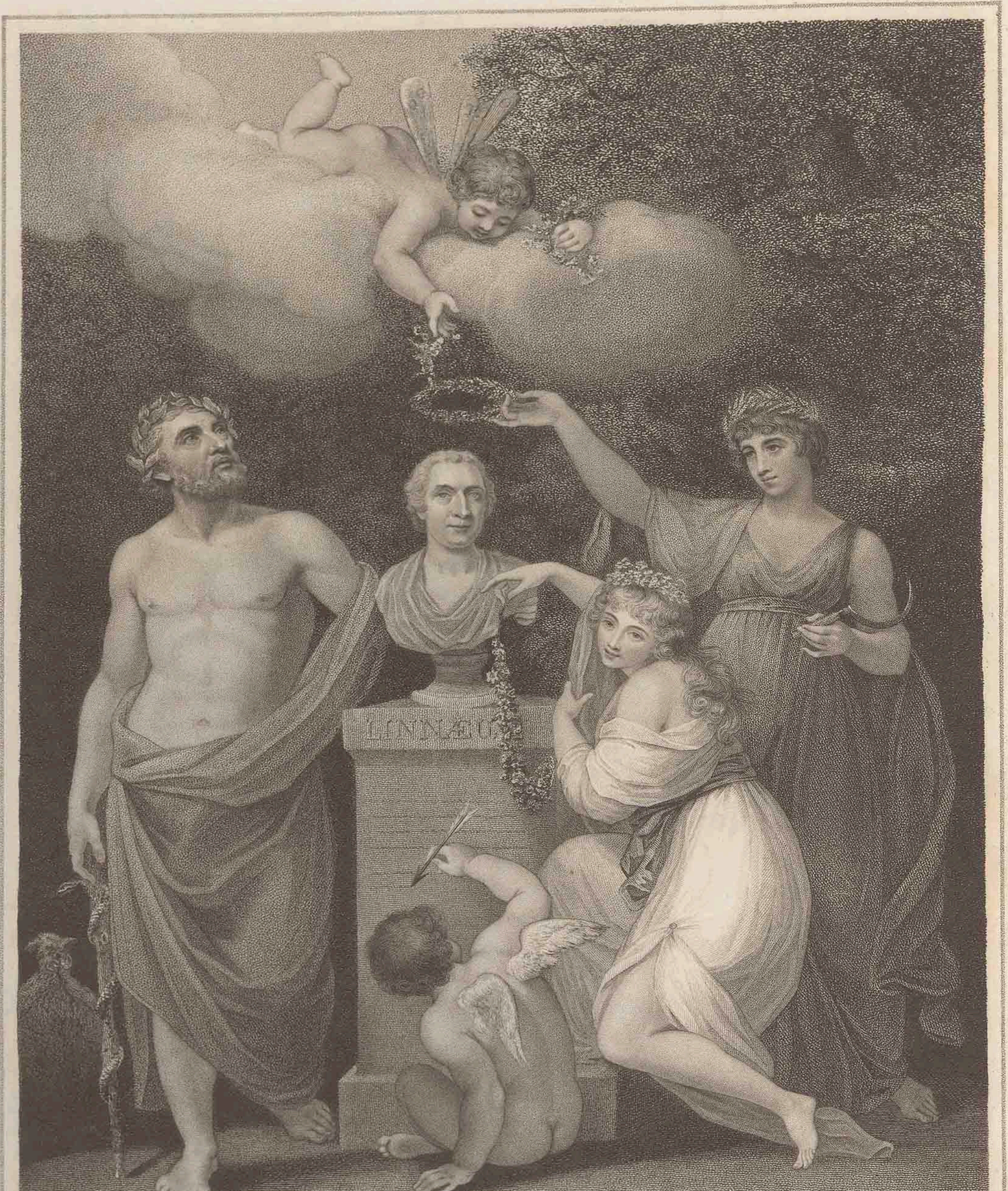




Ruſsell R.A. and Opie R.A. pinx^{t} Ridley sculp^{t}

CUPID, FLORA, CERES, and ESCULAPIUS,

Honouring the Bust of Linnæus.

London Publish'd by Dr Thornton, Duke Street, Grosvenor Square, May 1 1799.

THE
Philoſophy
OF
BOTANY,

Being

Botanical, and Philosophical

Extracts.

Including,

Tomkins ſcript   Vincent ſculpt

A
New
ILLUSTRATION
# of the
Sexual System
OF
Linnæus

BY

Robert John Thornton, M.D.

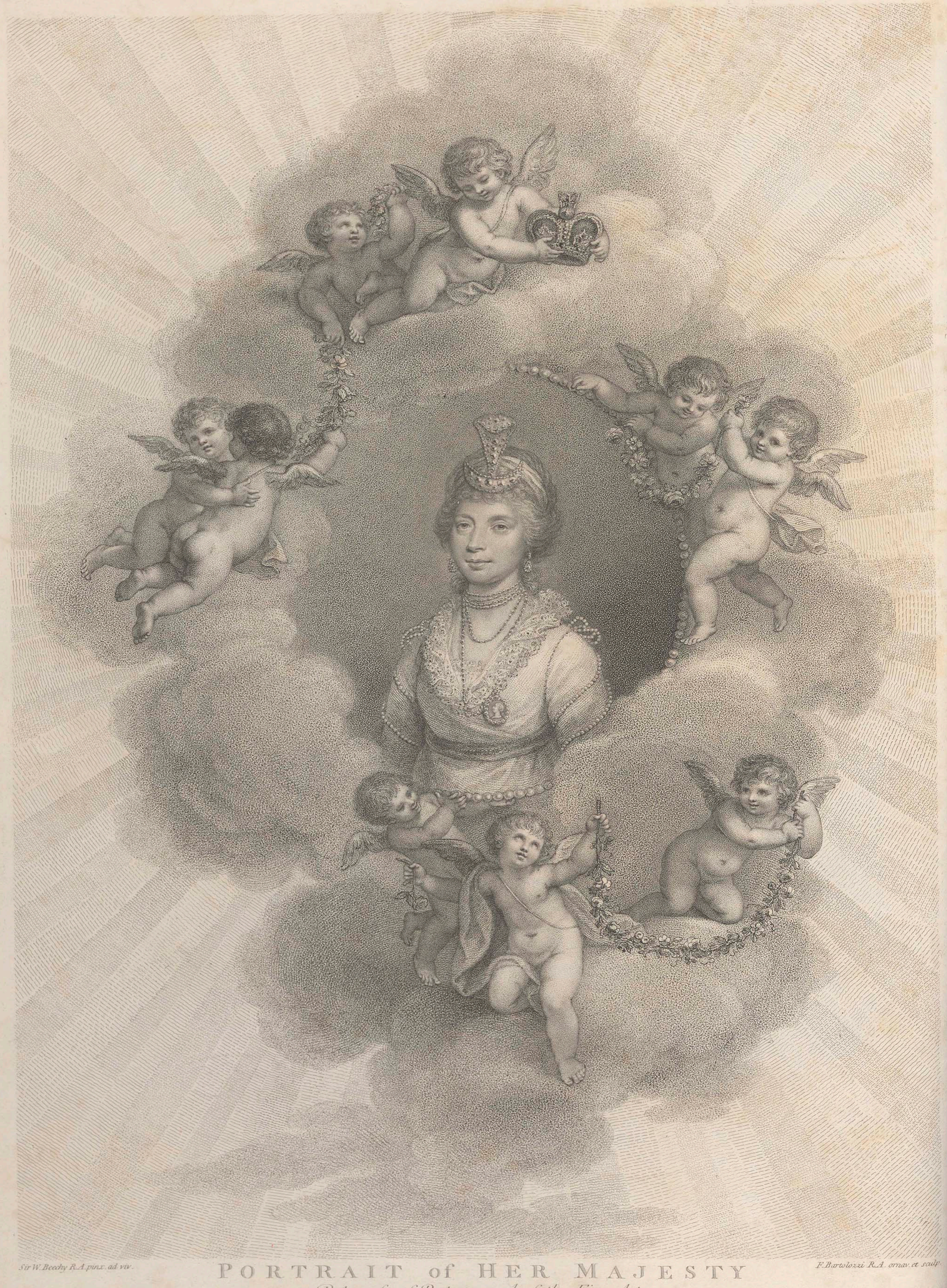
Late of Trinity College, Cambridge

PHYSICIAN to the GENERAL DISPENSARY;
Fellow of the London Medical Society, &c. &c.;
Lecturer on Medical BOTANY at Guy's Hospital;
Author of Medical Extracts on the Nature of Health;
And Letters to Dr. Beddoes on the Application and Theory of Pneumatic Medicine.

Vol: I.

Tomkins scr. Vincent sculp.

LONDON. Printed for the Author by T. Bensley 1799.



Sir W. Beechy R.A. pinx. ad viv.

F. Bartolozzi R.A. ornav. et sculp.

PORTRAIT of HER MAJESTY

Patroneſs of Botany, and of the Fine Arts.

London Published Jan.y 1.1799, by Dr. Thornton Duke Street, Grosvenor Square

DEDICATION
BY
PERMISSION
TO
Her most excellent Majesty
CHARLOTTE
QUEEN
of the
United Kingdom
OF
Great Britain and Ireland.

TOMKINS ſcr^{t} COOPER ſcu^{t}

DEDICATION,

BY PERMISSION,

TO

HER MOST GRACIOUS MAJESTY,

CHARLOTTE,

QUEEN OF GREAT BRITAIN, &c. &c.

MADAM!

In Eastern Language high and mighty Potentates are compared to lofty Trees which afford Food and Shade to the sun-burnt Traveller. In the more temperate Regions of the Earth, Kings and Princes are contemplated as the Sun, which sheds his benign Radiance every where, inspiring each Object with new Life and Refreshment: by the Concurrence, therefore, of all Nations, the great Attribute of Sovereignty is Protection; from conferring of which by Your Most Gracious Majesty, the Science of Botany in Great Britain owes its present Advancement; and this New Illustration of the Sexual System of the great Linnæus, its Foundation, which in Point of Magnificence is intended to exceed all Works of a similar Nature on the Continent, and to be not only, (by employing the first Artists in this Country,) a National Honour, but an Eternal Memorial of that Protection which is granted to Science by Your Most Gracious Majesty.

I have the Honour to subscribe myself,
MADAM!
With the profoundest Veneration,
Your Majesty's most obliged
And dutiful Subject,

ROBERT JOHN THORNTON.

DESCRIPTION
OF
THE FRONTISPIECE,
CONJOINTLY PAINTED BY
RUSSELL, R.A. Portrait Painter to the King, and OPIE, R.A.

THE BUST OF LINNÆUS,
FROM
A PORTRAIT
IN THE POSSESSION OF
Sir JOSEPH BANKS, Baronet, K. B.
PRESIDENT OF THE ROYAL SOCIETY, &c. &c.

I.

Sacred to great Linnæus' honour'd name,
A shady grove perpetuates his fame,
Which deck'd in honest pride by sculpture's hand,
See Admiration[*] bids his image stand,
To grace the garden's variegated scene,
The owner's pride, his study, and his theme,
Who now retiring, leaves the hallow'd place,
When Sol in western billows hides his face,
And gold-fring'd pearly clouds dissolve away,
And evening veils the glowing face of day.
Then first, the subtle archer-boy,
Beauty's offspring, winged Love,
Bounding on in wanton joy,
Springs forward to the laurel grove,

---

[*] In allusion to the bust of Linnæus which was raised in the botanic garden at Edinburgh by the illustrious Dr. Hope, late professor of Botany.

And grateful traces on the stone,
In golden lines his tribute gay,
Proud thus indelibly to own
Th' extension of his tender sway.[*]

II.

Light, fantastic, and elegantly free,
Next, Flora,[†] blue-ey'd goddess, jocund, see,
In snow-white vesture, half-pellucid, drest,
Through whose thin folds by Zephyrus carest,
A form celestial presses to the sight
In swelling symmetry. As Venus bright
She moves, that lively goddess of desire!
But looks the vestal maid to check the fire,
And breathes the rapturous delight of sense,
And smiles the beaming grace of innocence.
She weaves her varied wreath
In artless sweet simplicity,
While every flower her feet beneath
Springs upward to felicity,
Happy if pluck'd by Flora's hand,
Its blooming tints may help to sort
The garland which from fairy-land
The Goddess to the sage hath brought.

---

[*] The lines on the Pedestal of the bust were composed by Mrs. Lenox, whom Dr. Johnson presented one evening in a public company with a sprig of laurel in compliment to her great poetic genius. See the Life of Johnson prefixed to his Dictionary. They are as follows:

All animated Nature owns my sway;
Earth, Sea, and Air, my potent laws obey:
And thou, divine Linnæus, trac'd my reign
O'er Tree, and Herbs, and Flora's beauteous train;
Prov'd them obedient to my soft controul,
And gaily breathe their aromatic soul.

[†] The introduction here of Flora, Ceres, and Æsculapius, is emblematic of the advantages derived from the study of Botany to *Physic, Agriculture,* and as an *elegant Pursuit for Ladies.* Cupid is represented in allusion to the formation by Linnæus of the *Sexual System.* The Zephyr above denotes *Spring,* the season most favourable to the study of Botany. The fair forms of Flora and Cupid with the bust of Linnæus cannot fail to disclose to the eye of the observer the magic pencil of a Russell, and the figures of Æsculapius and Ceres, the nervous and masterly strokes of an Opie.

III.

Then nut-brown Ceres, as she walks along
Trilling in rustic phrase her ev'ning song,
When from the plenteous harvest she returns
Bearing the yellow wealth which labour earns,
Quick from the summit of the hill she spies
The honour'd bust, and soon a wreath she ties,
A golden chaplet, choice reward of heaven!
Unfading gift, to mortals rarely given!
And hastes away to join the lovely pair,
And pay with gratitude her homage there.
By the sparkling of her eye
Of the darkest hazel hue,
By her forehead arched high,
And tawny freckles not a few,
The bounteous maid is clearly seen,
Flush'd in ruddy glow of health,
Beauteous goddess of the plain,
Fruitful source of all our wealth.

IV.

Last reverend Age with hoary Wisdom joins
The youthful forms, who bow before thy shrine,
For lo! where sapient Æsculapius nigh,
Lifts with enthusiasm an enraptur'd eye,
And owns the debt his science owes to thee,
Great Northern genius, Sire of Botany!...
The knotty staff, the twining serpent, tell
Apollo's favour'd son, denoting well
The difficulties, and the cunning art,
Requir'd to parry Death's envenom'd dart.
Thus hoary Wisdom here combines
With Beauty, Usefulness, and Love,
And each their proper homage joins,
Unrivall'd Swede! thy worth to prove!

Thus manly Admiration stands,
And Cupid writes immortal fame,
While Females[*] use with lavish hands
Their flowers in honour of thy name!

Samuel Hull Wilcock.[†]

---

[*] The different modes of honour are here finely illustrated. The effect indeed of this picture throughout is greatly heightened by contrast. You have old age and infancy, male and female, fair and brown, animate and inanimate.

[†] This gentleman is the translator of the admired Zimmerman, and so ready in poetic composition, that one day mentioning how difficult it was to explain a picture in prose, " pictura est verum poema," " for a picture is in truth a poem," he took up his pen, and wrote as above extempore in my presence, which must plead with the indulgent reader for any inaccuracies, as well as the nature of the subject.

SECT. I.

PLAN OF THIS WORK.

> INCRESCUNT QUOTANNIS SCIENTIÆ, EMENDANTUR QUOTIDIE, ET AD FASTIGIUM SUUM OPTATUM SENSIM SENSIMQUE, PLURIUM VIRORUM OPERA ET STUDIO JUNCTIS, FELICITER PROPERANT.
>
> THUNBERG.

The Science of Botany is a study which, from its simplicity and beauty, and the Royal Protection it has met with, has been much cultivated of late years.

Its principles are few and unperplexed.

It serves but to engage the attention without putting the faculties to too strong an exertion.

A person who has a taste for this elegant pursuit is most employed when others would sink into a melancholy supineness.

A solitary walk in the fields, which to some is an insupportable burthen, is full of charms for him.

He finds an exercise for his intellectual powers where others have only a momentary gratification of the eye.

He beholds order and contrivance where the uninformed spectator observes but the splendor of colour.

He rises from the contemplation of the creation to the all-powerful CREATOR, and with the utmost reverence draws aside the veil which conceals the hidden mysteries of Nature: for if we go beyond the mere rules of classification, which bring us to a knowledge of each individual of the vegetable world, it is then that the prospect widens to our view, and new sources of curious investigation arise.

The object of this Work, therefore, will be to trace in as perspicuous a manner as possible the philosophic principles of Botany, from the earliest times, up to the present period, and by faithful and well executed Engravings of the several subjects of investigation, to render this curious and interesting inquiry level to every one's comprehension.

Following the order of Nature, I shall begin with the seed committed to the ground, and trace its various evolutions, until the root, stem, branches, and leaves are formed. I shall here chiefly dwell on the anatomy of the root, their diversity of forms, and office.

The object of my next consideration will be to display the organized structure of the stem and branches, when I shall consider the several juices of plants, with the motion of the sap.

Pursuing the course of Nature, I shall next contemplate the various appendages attached to the stems and branches, explaining the organization and design of each.

Next I shall examine into the structure and variety of leaves; their relationship to light; the evolution from them of oxygen, and other airs.

My next inquiry will be the food of plants, when I shall enter widely into the consideration of the principles of agriculture.

Arriving at the flower, I shall consider its structure; the uses of the several parts which compose it; when a full inquiry will be made respecting the Sexual Relationship, with a refutation of the objections which have been raised against this doctrine.

Thus far the Natural History of Botany.

I shall next lay before my readers an account of the origin of systems, when those of Rivinus, Tournefort, &c. will be given, with a full explanation of the Sexual System of Linnæus.

In the order of the discoveries, the lives of the several eminent Botanists will be comprehended, with their portraits, including the most celebrated Professors and Botanical Writers of the present day.

After this introduction, I shall commence with a translation of the Genera of Plants of Linnæus.

Statues have been raised, medals have been struck, paintings and engravings have been multiplied, to represent to the remotest generations the person of LINNÆUS, and many societies assuming the honour of his Name have endeavoured thereby to perpetuate his glory.

The most eminent Professors of Europe have been for years employed in favouring the world with editions of his Botanical Works; so that, added to the success they had in his life-time, they have not passed abroad through less than fifteen editions; and, having been translated into the German, French, and Spanish tongues, they have ceased to be confined solely to the learned.

The honour of first sending LINNÆUS's Genera forth in an English dress is due to a most respectable Society of Botanists at Litchfield, who early entered upon this difficult undertaking. But these gentlemen, instead of adopting the terms of LINNÆUS, invented for their work new English compound words, which, as being extremely inharmonious, and not more intelligible than the original Linnæan expressions, subjected their translation to criticism. The Rev. THOMAS MARTYN, Regius Professor of Botany at Cambridge, my venerable and learned master, confessing his dissatisfaction of what had hitherto appeared, presented a dissertation to the Linnæan Society " on the Language of Botany," which, being highly approved of by the illustrious President, Dr. SMITH, he was persuaded to strengthen and enforce his opinion in a larger work,* which has since met with universal approbation. Conceiving, therefore, that the public would be gratified by a new translation founded upon these principles, I have ventured upon this arduous task, and seize with pleasure the present opportunity of publicly expressing to these gentlemen my most GRATEFUL ACKNOWLEDGMENTS; to the former for the great encouragement he has given to this undertaking, and the many aids received; to the latter for his liberally resigning to me the botanical chair at Guy's Hospital, and other distinguishing marks of friendship; as also to Sir JOSEPH BANKS, for the use of his extensive library, and the honourable permission of copying his picture of LINNÆUS; to Dr. DARWIN, the greatest poet and philosopher of this age, for many invaluable suggestions on some parts of the vegetable œconomy; to my friend the Rev. JOSEPH TOWNSEND, a gentleman deeply versed in this, as in every other branch of polite literature; to Mr. CURTIS, a teacher of the greatest practical information, with whom I have frequently herborized; to Mr. WHEELER, Demonstrator of Botany, for his instructions in the Physic Gardens of Chelsea; and to the Rev. Dr. COLIN MILNE, a gentleman of profound erudition, whose Institutes of Botany,† had they been encouraged, would have superseded the necessity of the present work, and established both for him and his country an eternal monument of glory.

The FIRST VOLUME of this Work will include chiefly those plants, the flowers of which LINNÆUS saw in their living state. If we consider the various countries traversed by this great Botanist; the time which elapsed betwixt the first publication of his GENERA PLANTARUM and the last, a space of not less than five and twenty years, during which he superintended a botanical garden supported by the munificence of an illustrious prince, GUSTAVUS III, king of Sweden, and occupied the professorial chair; we cannot hesitate to pronounce, that he who is well acquainted with the exotic and hardy plants, which LINNÆUS himself viewed, and has so accurately described, has made no inconsiderable progress in Botany.

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* A Dictionary of the Terms used in Botany.

† Two parts of this most excellent performance have been published; one in the year 1771, the other in 1772; since which time no more have appeared.

A SELECTION of this nature possesses also a signal advantage. The Student, in commencing his studies, will not be terrified at the number of the Genera he is likely to meet with, nor be perplexed by very frequent and useless comparisons; for it is evident, that as the Groundsel and Chickweed are not to be found in any garden in India, so shall we not be able to find in our climate the Bucephalon (Bull's Head), with a multitude of other weeds the product of tropical regions: and as the traveller wants not a map of Africa, America, and Asia, who is making the tour of Europe, or the mariner a description of each star in the milky way, so will this first volume be adapted chiefly for the inhabitants of the more temperate climates of the earth.

We have, however, introduced into this Volume several of the ENGLISH GENERA, which were not personally known to LINNÆUS; for our information is so accurate on this head, from the gigantic labours of Mr. CURTIS in his unrivalled Flora Londinensis;* from the extremely elegant and extensive English Botany of Dr. SMITH;† the useful Flora Rustica of Professor MARTYN;‡ and the excellent Botanical Arrangement of British Plants by Dr. WITHERING;§ that we could have no difficulty in including all the British Genera.

Many EXOTICS, which fashion has rendered rather common, but which were not personally known to LINNÆUS, as the Fuschia, Begonia, &c. we have also inserted, and have at the same time corrected some unavoidable errors in their description.

---

[*] Six folio volumes of the Flora Londinensis, or Plants growing about London, have been already published.

[†] The public have been favoured with five volumes, in octavo; and the learned author pursues his design with unwearied industry.

[‡] We are sorry to inform the public, that this work has been discontinued for want of due encouragement. We trust, however, when peace is restored to Europe, it will then be resumed, and meet with that success it so justly merits.

[§] This work extends to four volumes in octavo.

Hence the Second Volume will contain only those plants, whose flowers Linnæus saw in a dried state, not unfrequently conveyed to him after a very long and tempestuous voyage: or such as he was able to obtain some imperfect account of from travellers. This part of his elaborate performance has already undergone the greatest changes; so that when we compare Linnæus with Schreber's edition of Linnæus, and oftentimes even Linnæus with himself, we can hardly recognize the same features; and it has yet to undergo much alteration.[*]

In order still further to facilitate the progress of the young Botanist, and to avoid the objection which has frequently been raised against the Sexual System, I have also attempted the reduction of the classes; and to give still greater simplicity to this elegant science, with the greatest diffidence have ventured upon the formation of Tables, possessing the most obvious discriminating characters, by which it is hoped the Student will in a few minutes be enabled to discover the Generic Name of each unknown plant he may have gathered either in the fields or garden; and then, by turning to the Genus, whose number is expressed in the Table, he will find afterwards a full description of the whole flower.

I here beg leave to solicit the candour of my readers, when I assure them, that I would gladly have resigned this expensive and hazardous undertaking to others, who have dedicated nearly their whole lives to this science,

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[*] I trust the candid reader will not interpret this assertion as any impeachment to the fidelity of this great genius; for, under such circumstances, who could have done better, who indeed could have done so well? But lest any enthusiastic and blind admirer of Linnæus should not give his immediate assent to my assertion, I will produce for him examples of each kind, which may also serve to apologize for my New Illustration.

First Edition of the Genera Plantarum.	*The last Edition.*
BOERHAAVIA† is a plant of the Class Triandria, Order Monogynia.	BOERHAAVIA* is a plant of the Class Monandria, Order Monogynia.
Calyx, scarcely any, the margin extremely minute, crowning the germen.	Calyx, none.
Corolla, one-petalled, campanulate, erect, five-angled, quinquefid, the *divisions* emarginate.	Corolla, monopetalous, campanulate, erect, five-angled, plaited, intire.
Stamina, *Filaments*, three, short. *Anthers* small.	Stamen, *Filament*, one, short. *Anthers*, twin, globular.
Pistillum, *Germen* below the receptacle. *Style* thread-form, erect. *Stigma* obtuse.	Pistillum, *Germen* beneath, angled, oblong. *Style* thread-form, short. *Stigma* kidney-form.
Pericarpium, a *Capsule* turbinate, sulcate, unilocular.	Pericarpium, none.
Seed, solitary.	Seed, one, oblong, narrower below, sex-angular.
Obs. The mark † implies that Linnæus had a dried specimen of the plant whence he took his description.	Obs. The mark * implies that Linnæus saw the plant in its living state, whereby he corrected the errors of its description in his first edition.

and are therefore more adequate to so extensive a plan, had I conceived it probable that such a work would have appeared. My Apology, therefore, for becoming a public Instructor in Botany is, that

I LABOUR TO BE USEFUL;

and, in consideration of the Motive, every generous mind will pardon those Errors

> ...... quas aut incuria fudit,
> Aut humana parum cavit natura....
> Hor.

Last Edition by Linnæus.	*Schreber's Edition of Linnæus.*
BEGONIA is a plant of the Class Polygamia, Order Monoecia.	BEGONIA † is a plant of the class Monoecia, Order Polyandria.
Incomplete Flower, male.	Incomplete Flowers, male.
Calyx, none, unless you take the Corolla for it.	Calyx, none.
Corolla, four-petalled, patent, regular, *two opposite petals* lanceolate, *the two others* ovate, emarginate, broader.	Corolla, four-petalled, patent, regular, *the two exterior opposite petals* broad-ovate, united at the base, *the interior ones* smaller.
Stamina, *Filaments* numerous, shorter than the corolla, capillary. *Anthers* roundish.	Stamina, *Filaments* numerous (ten to fifty or more), capillary, short, inserted on the receptacle, in some plants the filaments are united at the base. *Anthers* oblong.
Pistillum, caducous.	* * * * *
Complete Flowers.	Incomplete Flowers, Female.
Calyx, none, in whose place it bears a germen.	Calyx, none (unless the two *bractiæ* at the base of the germen be reckoned as such.)
Corolla, five-petalled, obcordate, oblong, patent.	Corolla, petals five or six, ovate, obtuse, patent; the two exterior, or three larger, equal; the three alternate interior, less, but alike equal.
Stamina, numerous *Filaments*, shorter than the corol, capillary. *Anthers* roundish.	* * * * *
Pistillum, *Germen* beneath, triangular, with membranous angles, tricuspid, erect. *Style* three, bifid, the length of the stamina. *Stigma* globose.	Pistillum, *Germen*, beneath, triangular, with membranous angles, one larger. *Style* three, short. *Stigma* oblong, or globose.
Pericarpium, triangular, trilocular, with three longitudinal wings.	Pericarpium, a *Capsule* triangular, three-winged; the *wings* longitudinal: the third large; trilocular, three-valved: the *valves* sulcated in the middle, with gaping angles; the *partitions* membranous, transverse.
Seeds, numerous small.	Seeds, numerous, extremely minute. *Receptacles* three, membranous, affixed to each internal angle of the chamber, parted, bearing seeds on both sides.
Obs. No mark whatever implies that the description is derived by Linnæus from some author or the relation of some traveller. It is seen from this account that Linnæus was even misinformed of the class and order; and speaking of the male flower he talks of a Pistillum!	Obs. The mark † implies that Schreber saw a dried specimen of this plant, by which he corrected the mistakes in the description given of it by Linnæus in the last edition of his Genera Plantarum.

AN ODE.

SPRING! thy impatient bloom restrain,
Nor wake so soon thy genial pow'r,
For deeds of death must hail thy reign,
And clouds of fate around thee low'r.

Ah! not in all thy store of charms
Can gen'rous hearts their comfort find,
Or lull to peace the dread alarms
Which rack the friends of human kind.

In vain thy balmy breath to *me*
Scents with its sweets the ev'ning gale;
In vain the violet's charms I see,
Or fondly mark thy primrose pale.

To me thy softest zephyrs breathe,
Of sorrow's soul-distracting tone,
To me thy most attractive wreath
Seems ting'd with human blood alone.

Arrest thy steps, thou source of love,
Thou genial friend of joy and life!
Let not thy smile propitious prove
To works of carnage, scenes of strife.

Bid WINTER all his frowns recall,
And back his icy footsteps trace;
Again the soil in frost inthrall,
And check the *War-fiend's* murd'rous chace.

Ah *fruitless prayer!* thy hand divine
Must on the teeming SEASON lead,
And (*contrast dire!*) at war's red shrine
Must let unnumber'd victims bleed.

ANONYMOUS.

The following are

SELECT PORTRAITS

of

Living Botanists,

or

But Lately Deceased;—

The Brightest Ornaments

of their

Respective Countries,

and the

Age in which we live;—

Whose Laurels are for glorious Conquests

over

NATURE,

Whose Actions from other Mortals

Are veiled

In impenetrable Darkness,

SHE, only, condescending

To disclose HER ravishing Beauties

To those

Who subdue HER by the Powers

of an

All-searching Mind:—

By the *Writings*, or *Countenance* of whom,

Added to *Royal Patronage*,

The present expensive, and hazardous Work,

Like a trembling Dove,

Has been *enabled* to venture abroad,

When Nations are grappling

With neighbouring Nations,

This was
a century & a half
ago —

And the Deluge of Blood has nearly arrived at its Acmé,

Seemingly never more to cease among infuriate Mortals;—

as a

SOLACE

To the Scientific World amidst such self-created Misfortunes;—

a

TRIBUTE

Grateful to a more fortunate Posterity,

Better enabled justly to appreciate what have, hitherto, been exclusively styled,

The Arts of Peace:—

And, lastly, as a

SINCERE TESTIMONY

of my

Veneration, and Gratitude,

For such Aids derived to this Work,

from

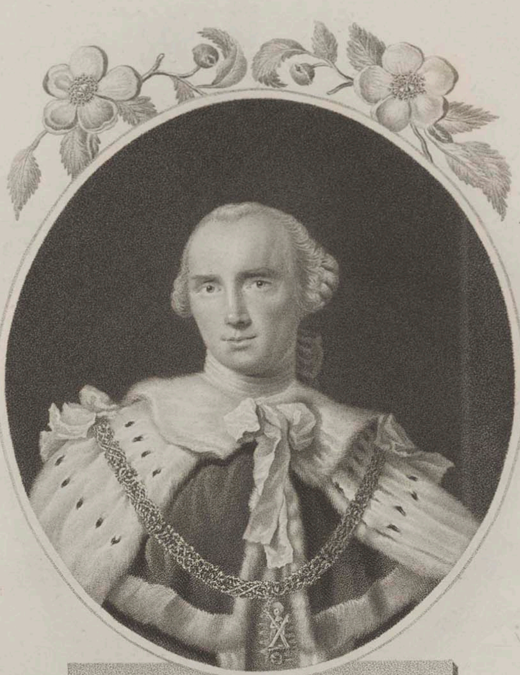
Such Transcendent Talents!

THE LIST OF PORTRAITS.

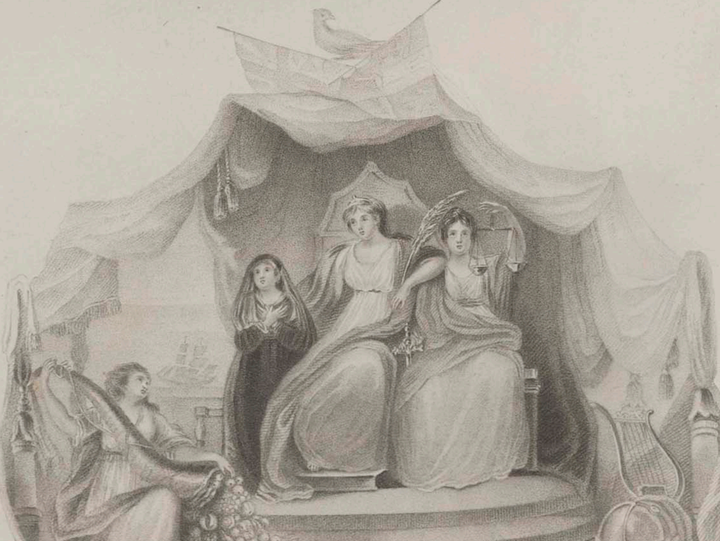
Bute, the Earl of, First Lord of the Treasury	Patrons of Botany, and great Cultivators of the Science.
Banks, Right Hon. Sir Joseph, President of the Royal Society	
Smith, James Edward, M.D. F.R.S.	Pres. and Institutor of the Linn. Soc.
Lambert, Aylmer Bourke, Esq. F.R.S.	Vice-President of the Linnæan Society.
Martyn, Rev. Thomas, F.R.S.	Professors of Botany, and Lecturers in the three British Universities.
Williams, George, M.D. F.R.S.	
Rutherford, Daniel, M.D. F.R.S. Pres. of the Royal Ed. Coll.	
Lamarck, Jean Baptiste, F.R.S.	Professors of Botany, and Lecturers of the National Institute at Paris.
Jussieu, Antoine de, F.R.S.	
Desfontaines, ——, F.R.S.	
Rousseau, Jean Jaques, F.R.S.	Amateur, and Promoter of the Science of Botany.
Darwin, Erasmus, M.D. F.R.S.	Poetic Writers on Subjects of Botany.
Shaw, George, M.D. F.R.S.	
Hill, Sir John, Knight of the Polar Star	Botanical Physiologists.
Hales, Rev. Stephen, F.R.S.	
Ingenhousz, Jean, M.D. F.R.S. Aulic Counsellor.	
Bonnet, Charles de, F.R.S.	
Hooper, Robert, M.D.	
Miller, Philip, F.R.S.	Practical Authors on Botany.
Sibthorpe, John, M.D. F.R.S.	
Milne, Rev. Colin, F.R.S.	
Withering, William, M.D. F.R.S.	
Curtis, William, F.R.S.	
Aiton, William. F.R.S.	
L'Heritier, F.R.S.	
Woodville, William, M.D. F.R.S.	Writer on Medical Botany.
Pulteney, Richard, M.D. F.R.S.	Historian.
Young, Arthur, Esq. F.R.S.	Agriculturist.
Townsend, Rev. Joseph	Voyager.

This list would have greatly increased, and the portraits of Sennebier, Dr. Stokes, Rev. Dr. Goodenough, the Rev. Richard Relhan, John Stackhouse, Esq. and Col. Velley, &c. &c. would have graced the pages of the present Work, had not *its limits*, from the unpropitious state of the times, been obliged, in some measure, to be *contracted*; and it is therefore hoped, that no offence will arise from the *present Selection*, from among a host of deservedly esteemed great men, who at this period are cultivating and extending the lovely Science of Botany.

N. B. The Heads of the older Botanists, as Grew, Malpighi, Ray, Vaillant, Duhamel, Tournefort, Linnæus, &c. will be found in their respective places in this Work.



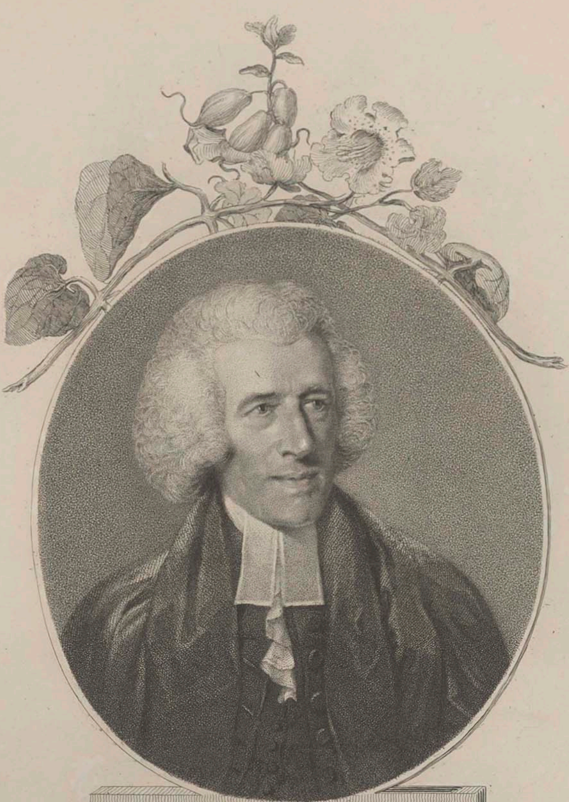
EARL of BUTE
THE MÆCENAS of BOTANY.



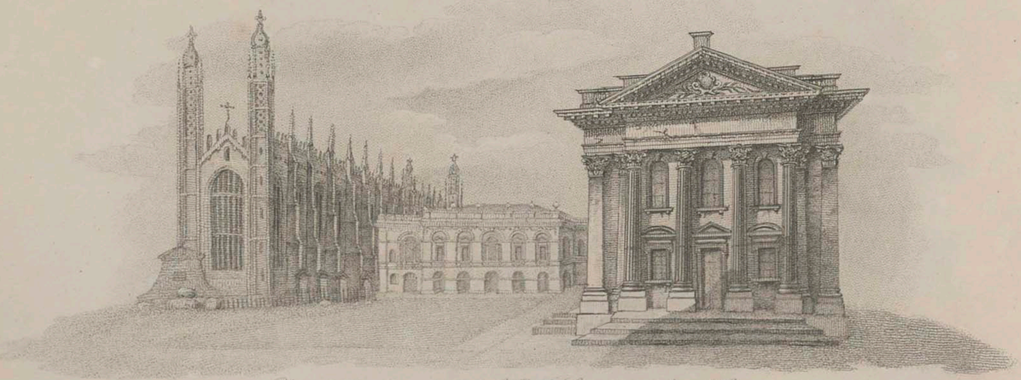
An Allegorical Representation of the Prosperity of Great Britain under Lord Bute's Administration.

Uwins del. *Caroline Watson sculp.*

Ramsay, Portrait Painter to the King, pinx^t. *Caroline Watson, Engraver to her Majesty, scu*



The Revd THOMAS MARTYN, B.D. F.R.S.
Regius Profeſsor of Botany in the University of Cambridge.

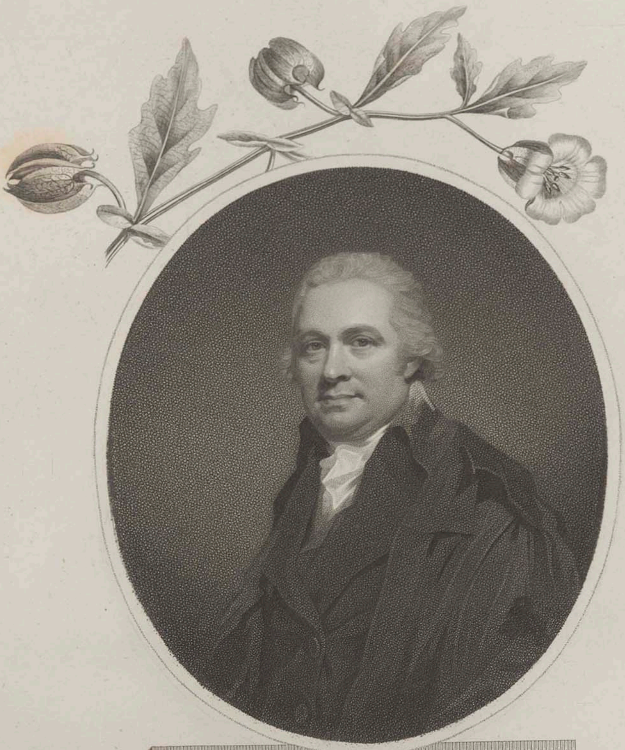


View of King's College Chapel, the Public Library, and Senate House.

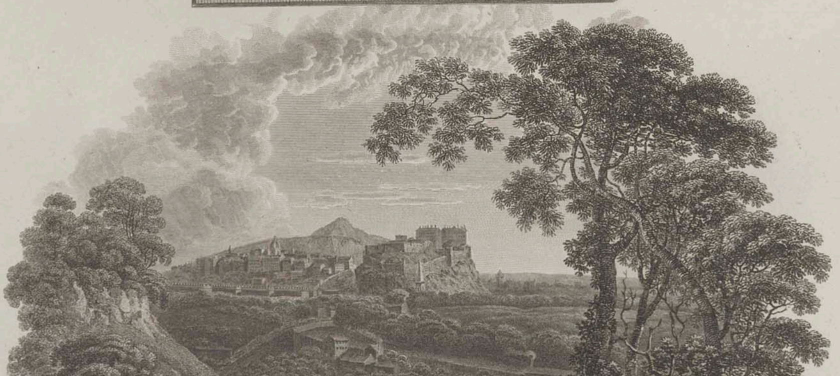
Ruſsell R.A. Portrait Painter to their Majesties, pinx^{t}.

Vendramini sculp^{t}.

London, Published for Dr Thornton, June 1. 1799.



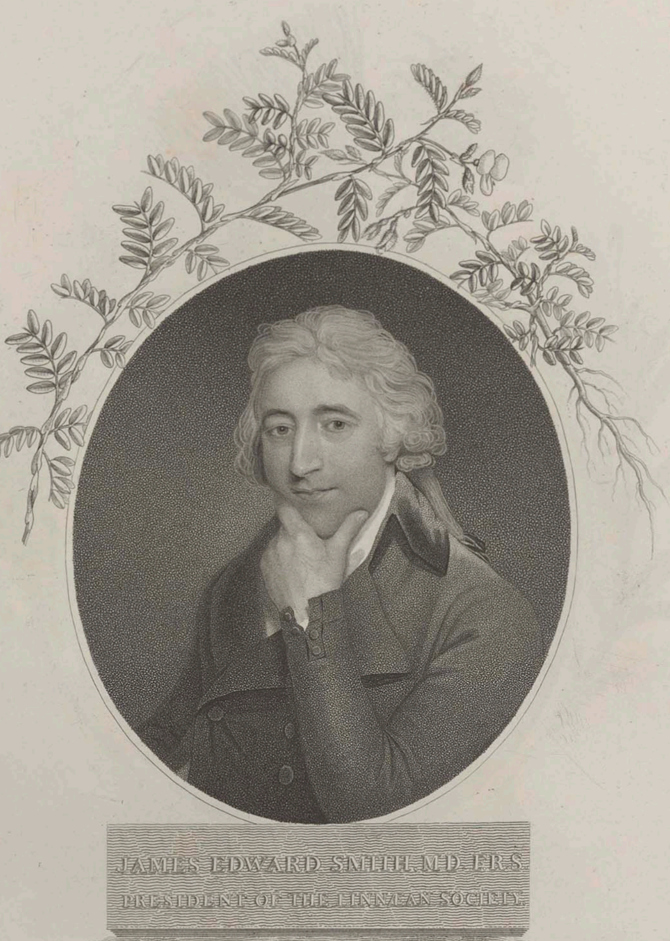
DANIEL RUTHERFORD, M.D. F.L.S.
Profeſsor of Botany in the Univerſity of Edinburgh.



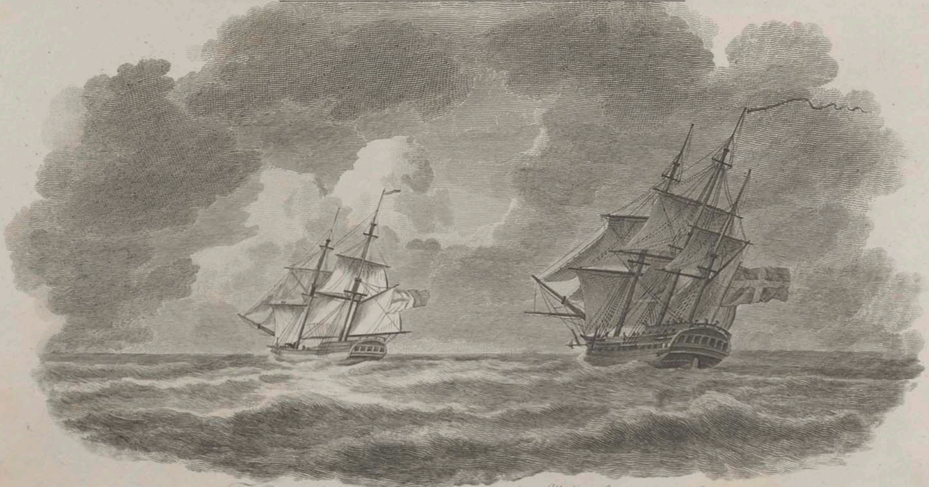
A distant View of Edinburgh.

Raeburn pinxt *Holl sculpt*

London, Published by Dr Thornton, June 1. 1804.



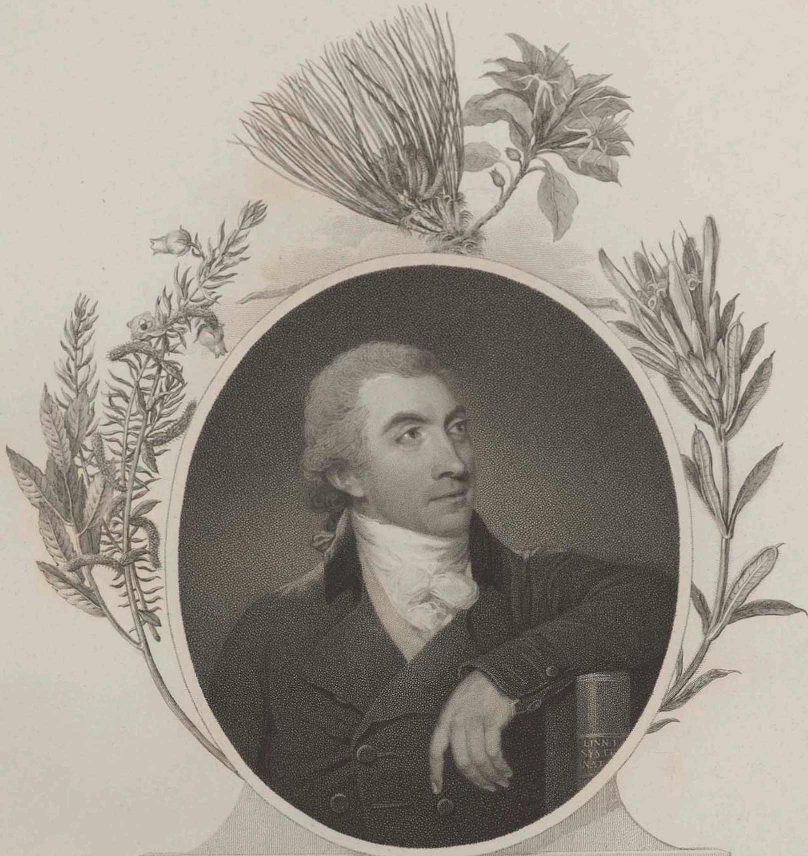
JAMES EDWARD SMITH. M.D. F.R.S.
PRESIDENT OF THE LINNÆAN SOCIETY.



The Pursuit of the Ship containing the Linnæan Collection by order of the King of Sweden.

R.A. Portrait Painter to their Majesties, pinx^t Ridley sculp^t

London. Published for Dr Thornton March 25, 1800.

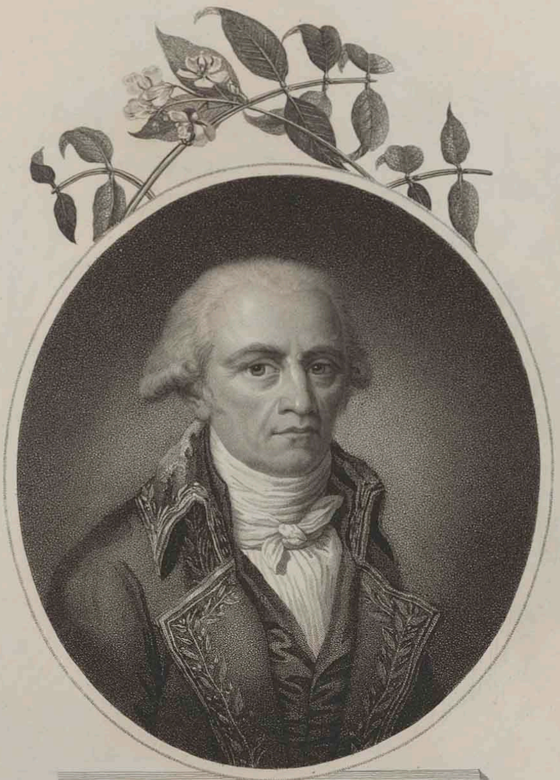


AYLMER BOURKE LAMBERT Eſq^{r}. F.R.S.
Vice President of the Linnæan Society.

Reinagle A.R.A. ornavit. *Landseer, Engraver to the King, sculp.*

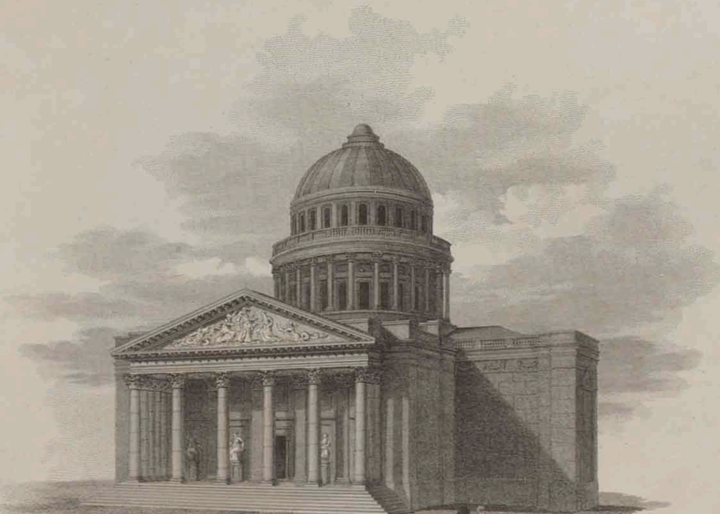
Ruſsel, Portrait Painter to their Majesties, pinx *Holl sculp.*

London, Published by D^{r}. Thornton, April 20th. 1805.



M. LE CHEVALIER DE LAMARCK,

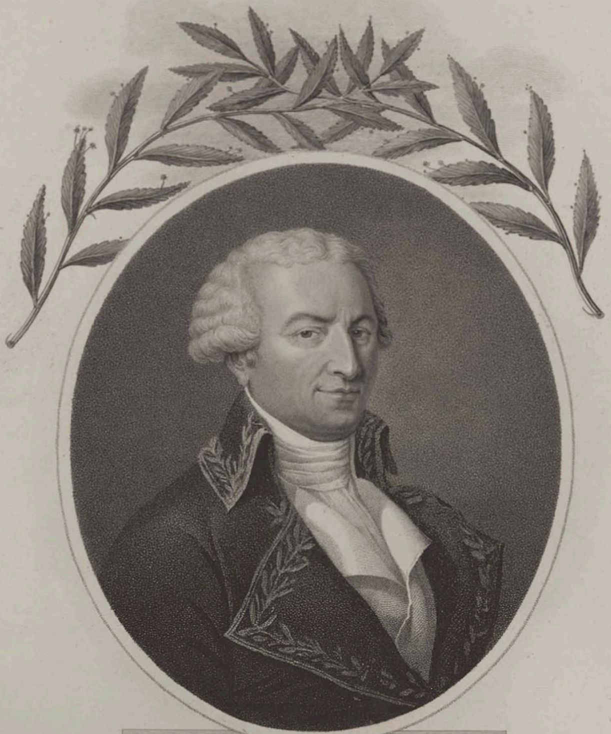
Profeſsor of Botany^{y} of the National Inſtitute.



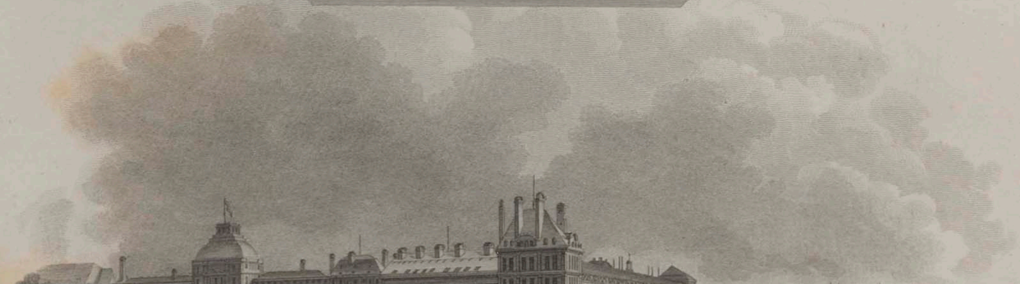
The Pantheon at Paris.

pinx^{t} *Hopwood sculp^{t}*

London. Published by D^{r}. Thornton Decr. 1805.



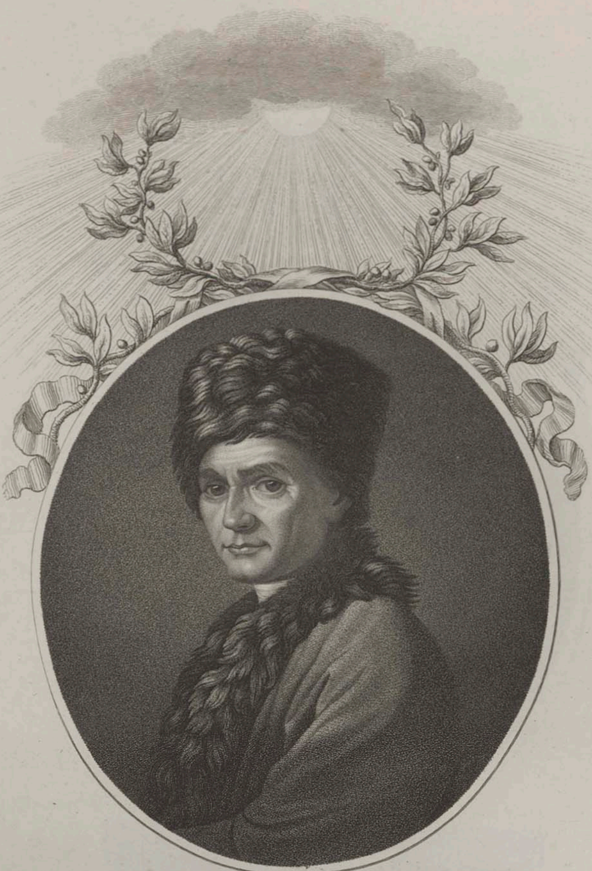
ANTOINE DE JUSSIEU, N.I.
Profeſsor of Botany of the National Inſtitute.



View of the Thuilleries at Paris.

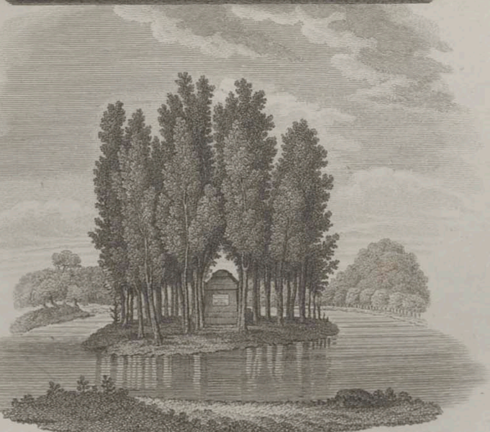
Thevenin pinx.ᵗ Evans sculp.ᵗ

London. Published by Dr. Thornton. March 1, 1803.



J. J. ROUSSEAU,

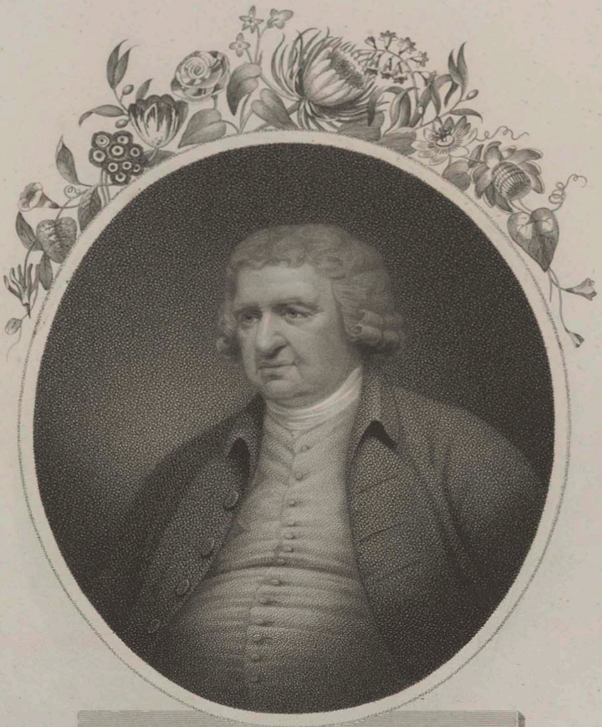
AUTHOR OF LETTERS ON BOTANY, &c.



The Tomb of Jean Jaque Rousseau

Ramsay Portrait Painter to the King pinxt
Caldwall sculpt

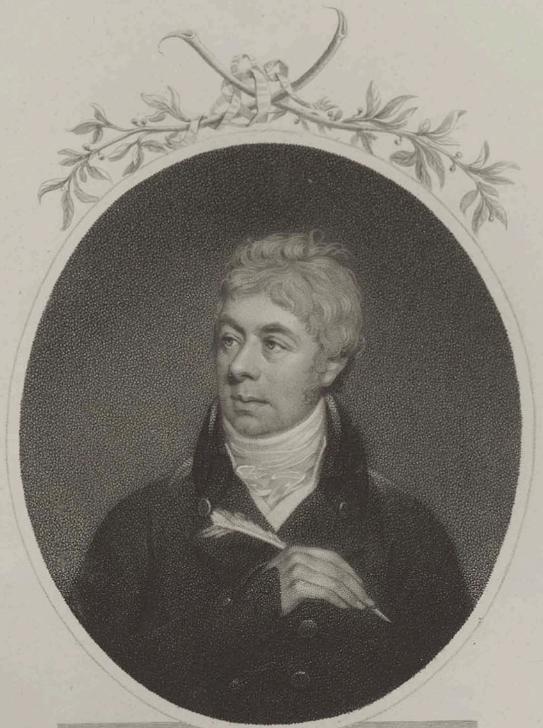
London Published July 1.1801, by Dr Thornton Hinde Street



ERASMUS DARWIN, M.D.F.R.S.
AUTHOR OF THE LOVES OF THE PLANTS.

R. Cosway del.
T. Milton sc.

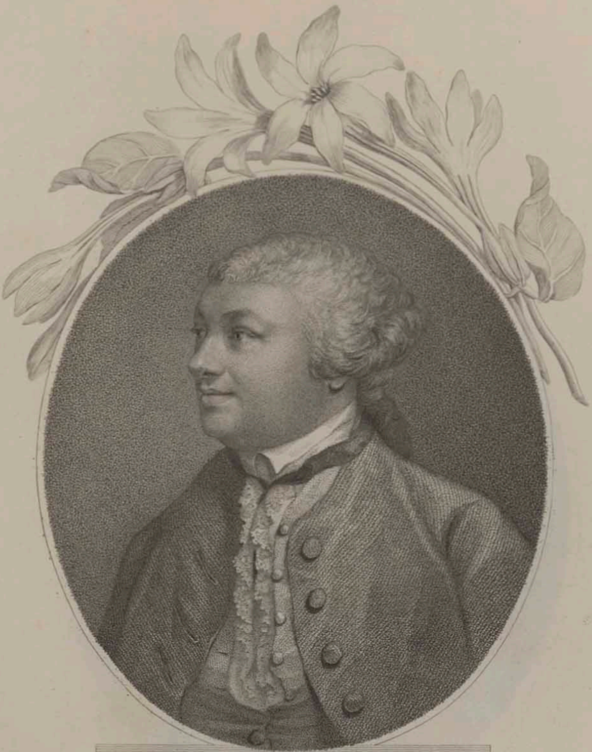
London, Published by Dr. Thornton, No. 1, Hinde St. Manchester Sq. February 1, 1803.



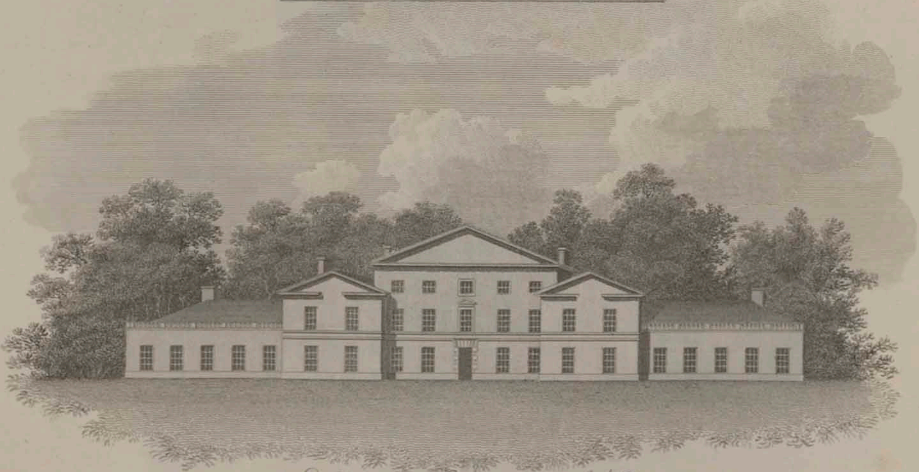
GEORGE SHAW, M.D. F.R.S.
AUTHOR OF GENERAL ZOOLOGY.

Back View of the British Museum.

Ruſsell, R.A. Portrait Painter to their Majesties, pinx^{t} Holl sculp^{t}



SIR JOHN HILL, M.D.
KNIGHT OF THE POLAR STAR,
First Superintendant of the Royal Gardens at Kew.

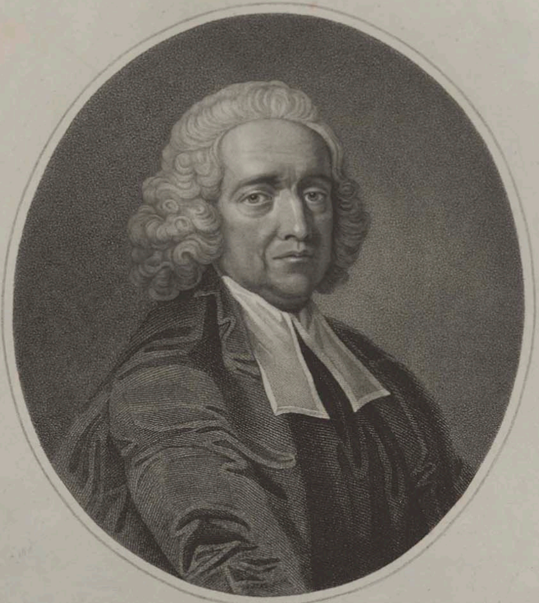


A View of the Royal Palace in Kew Gardens

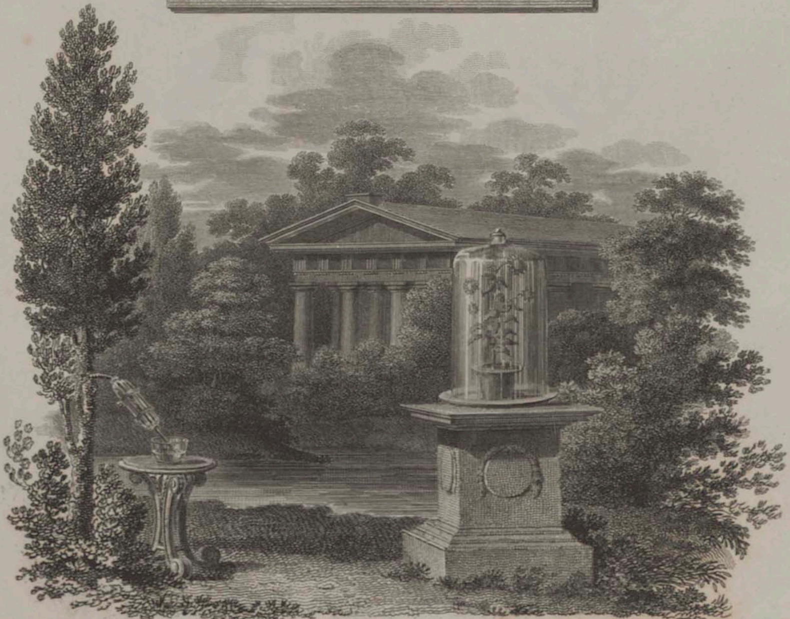
Coates R.A. pinxt

Vendramini sculpt

London, Published for Dr. Thornton, Novr. 1. 1799.

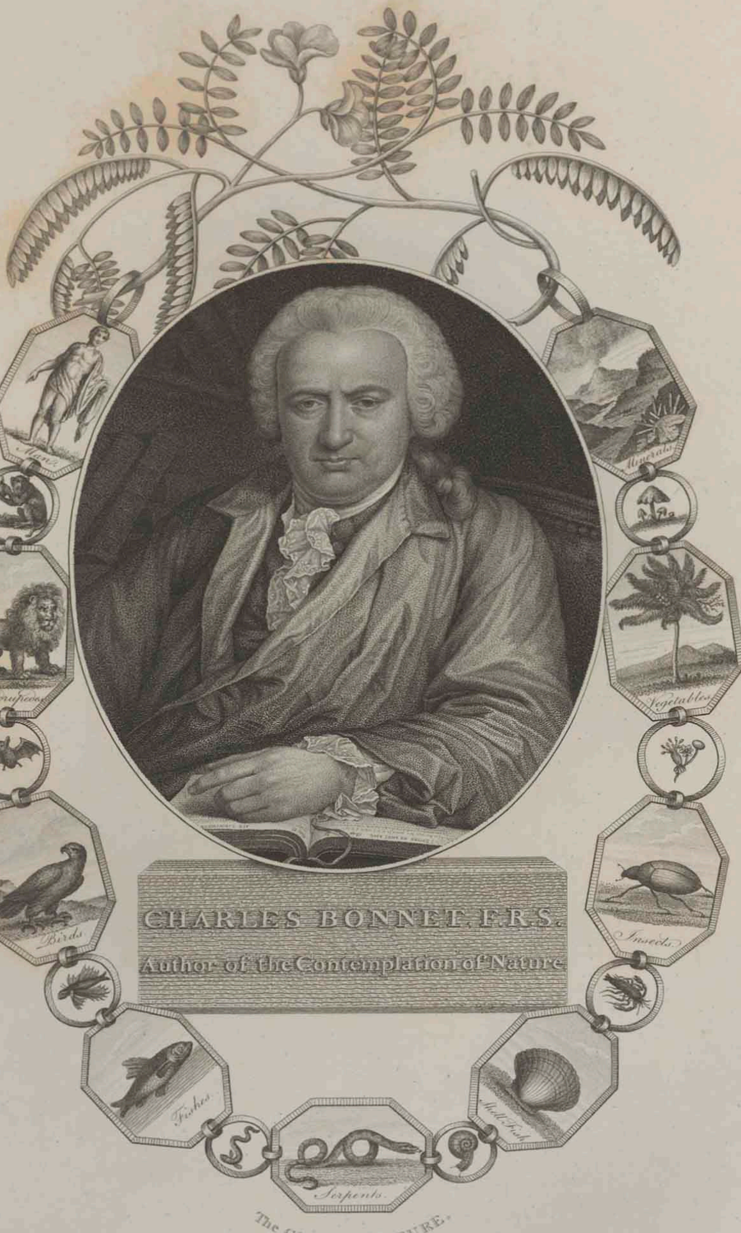


THE REV.D D.R STEPHEN HALES, F.R.S.
AUTHOR OF VEGETABLE STATICS.



Coates R.A. pinx.t

London, Published by D.r Thornton Dec.r 1

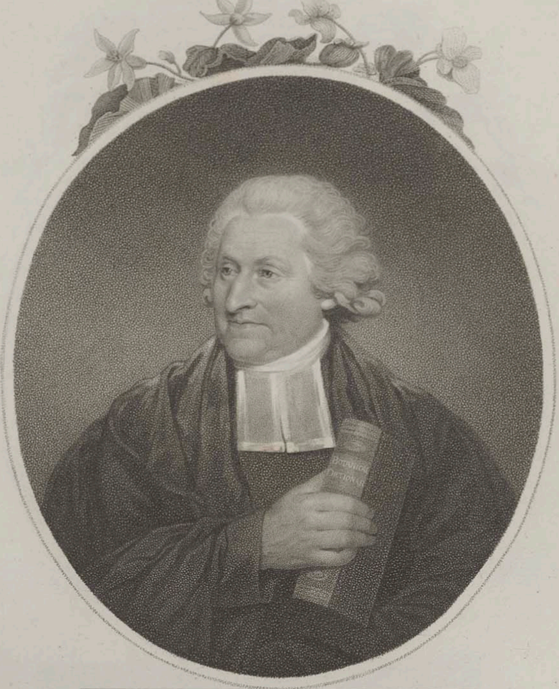

Man.
Minerals.
Quadrupedes.
Vegetables.
Birds.
Insects.
Fishes.
Shell-Fish.
Serpents.

CHARLES BONNET, F.R.S.
Author of the Contemplation of Nature

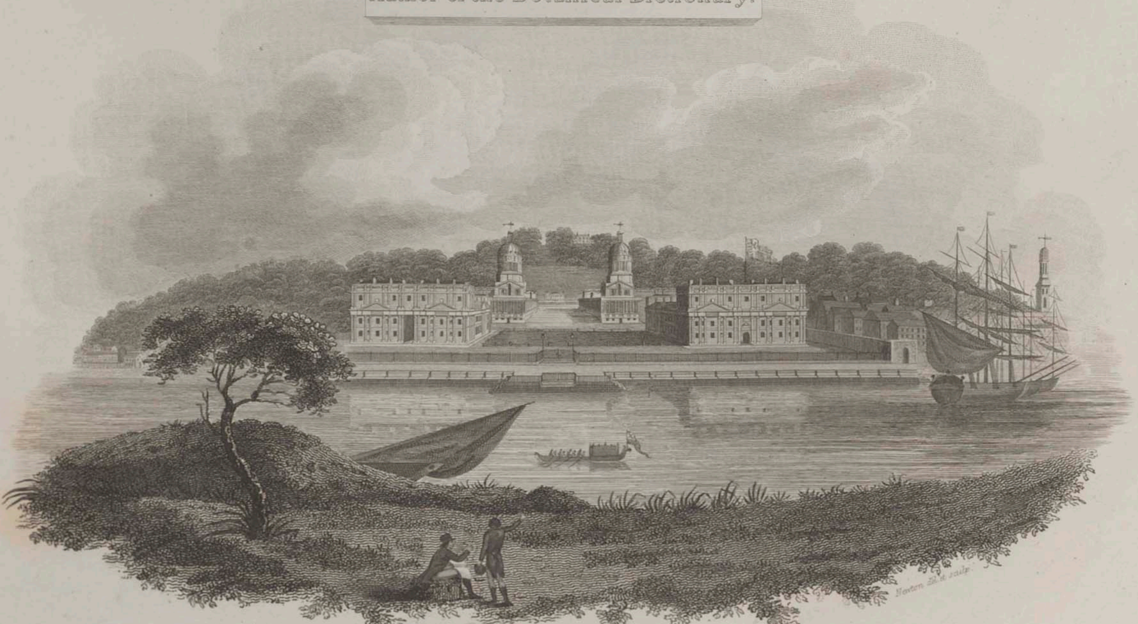
The CHAIN of NATURE.

Caldwall sculp^t.

London, Published by D^r. Thornton, May 1.1802.



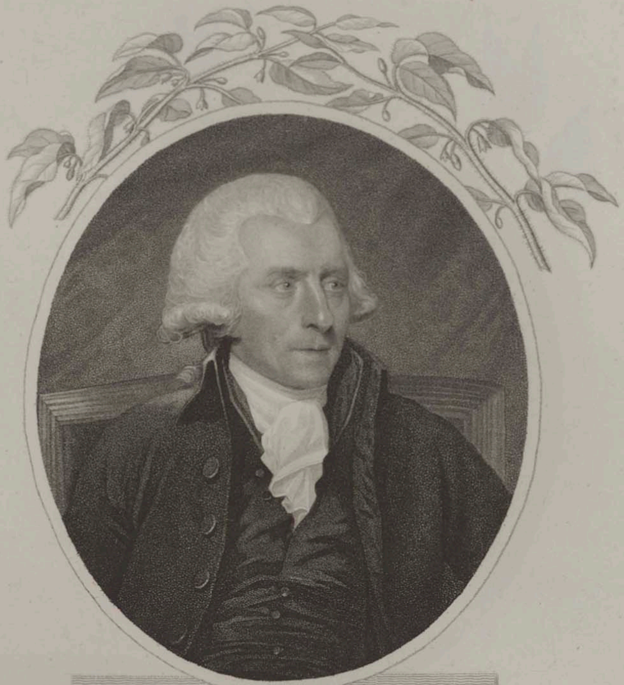
THE REVD. DR. COLIN MILNE, F.R.S.
Author of the Botanical Dictionary.


Newton Del. et sculp.

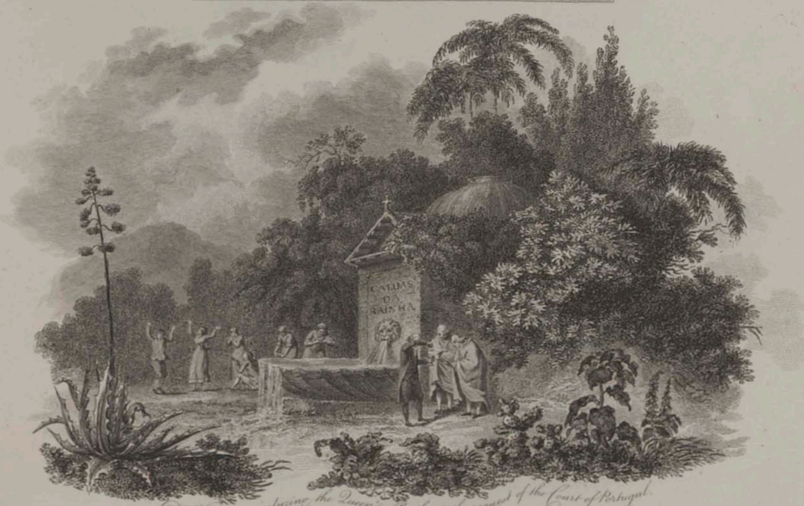
A View of Greenwich Hospital

Ruſsell, R.A. Portrait Painter to their Majesties, pinxt. *Holl sculpt.*

London, Published for Dr. Thornton, 1804.



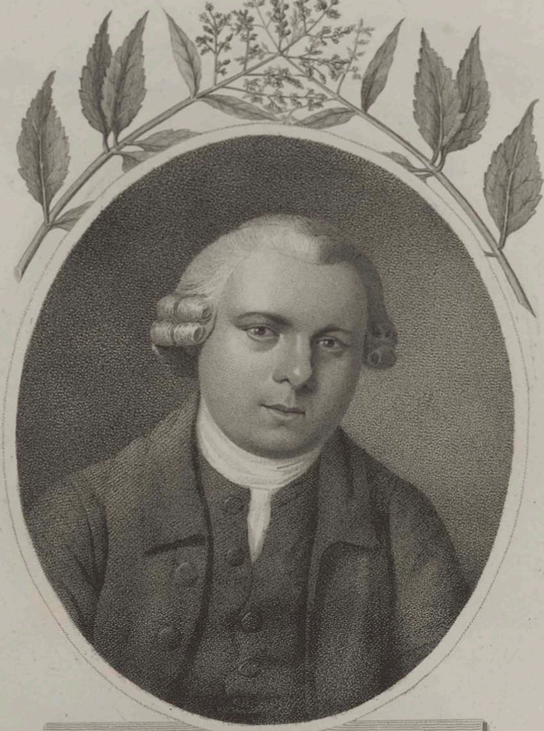
WILLIAM WITHERING, M.D. F.R.S.
FELLOW OF THE LINNÆAN SOCIETY.



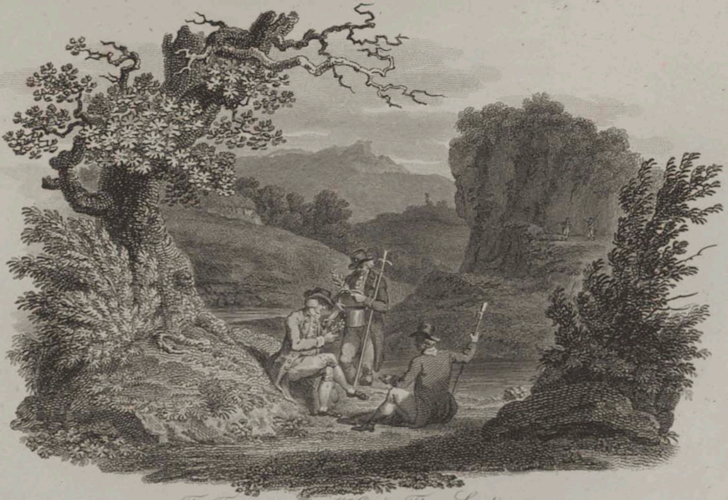
Dr. Withering analyzing the Queen's Bath at the request of the Court of Portugal.

Breda, Portrait Painter to the King of Sweden, pinxt. Ridley sculpt.

London Published by Dr. Thornton, Novr. 15. 1801.



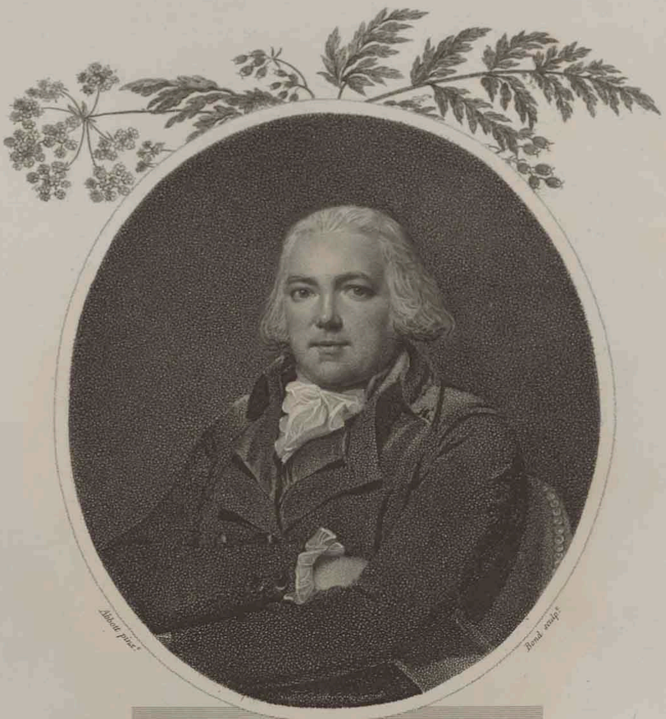
WILLIAM CURTIS, F.L.S.
AUTHOR OF THE FLORA LONDINENSIS



The Frontispiece to Mr. Curtis' Flora Londinensis.

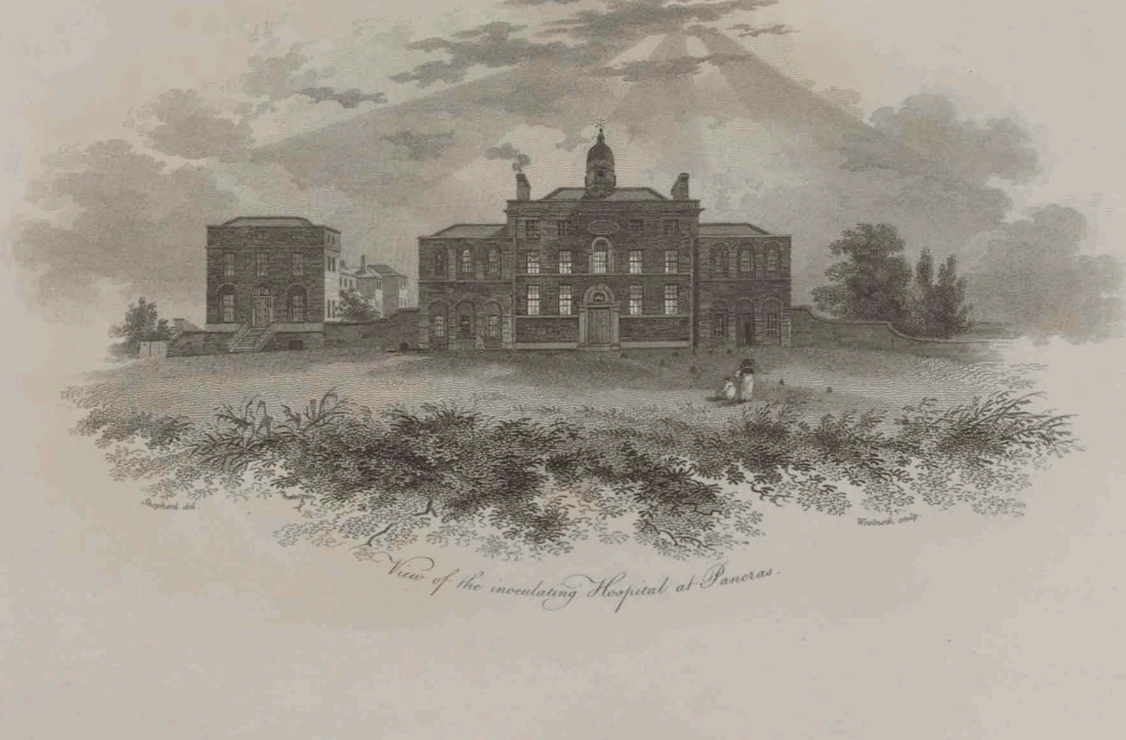
Evans sculpt.

London Published by Dr. Thornton, March 1 1802.


Abbott pinxt
Bond sculpt

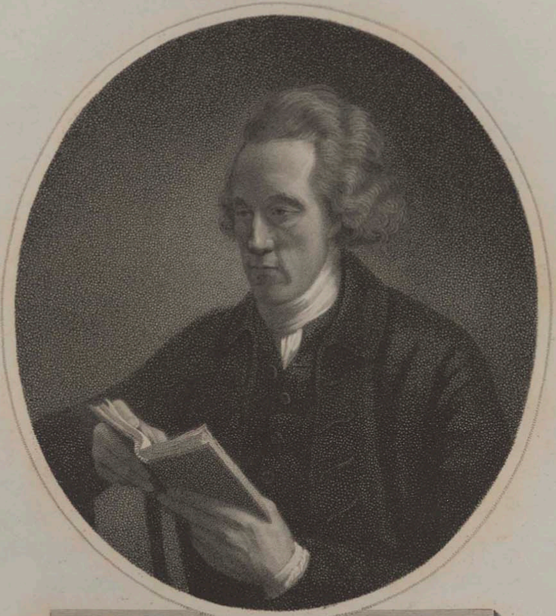
WILLIAM WOODVILLE, M.D. F.R.S.

Author of Medical Botany; &c.


Shepherd del.
Woolnoth sculp.

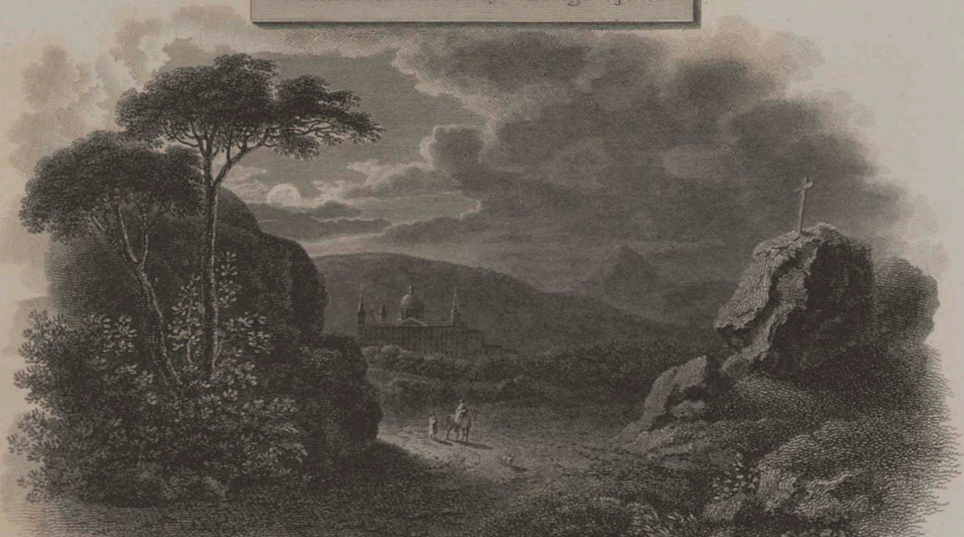
View of the inoculating Hospital at Pancras.

London, Published by Dr. Thornton, August 1, 1806.



The REV.D JOSEPH TOWNSEND, M.A.

Author of a Journey through Spain.



The Rev.d Jo.s Townsend pinx.t

Milton sculp.t

View of the Escurial by Moon-Light

R.A pinx.t Ætat.s suæ XIX

Holl sculp.t

SECT. II.

THE THREE KINGDOMS OF NATURE.

Hail, Sovereign Goodness! All-productive Mind!
On all THY works, THYSELF inscrib'd we find:
How various all, how variously endow'd!
How great their number, and each part how good!
How perfect then must the Great Parent shine,
Who, with one act of energy divine,
Laid the vast plan, and finish'd the design!

Blacklock.

Let us suppose a man just fashioned by the hands of his Creator, perfectly possessed of all his faculties, taken, to employ the allusion of Cicero[*], from the profoundest cavern of the earth, and made to behold at once the wonders of creation. We will suppose the sun just rising, and streaking with gold the clouds, the mists removing like a veil from the mountain's top; in a few minutes his effulgent rays darted every where, and the whole scene at once becoming animated! After the first powerful impression from this display of the charms of nature, like our first parent*, he would arrange this beautiful assemblage in his mind, and form three classes or kingdoms of nature, the Mineral, Vegetable, and Animal.

---

[*] Aristotle very well observes, 'If there were men, whose habitations had been always under ground, in great and commodious houses, adorned with statues and pictures, furnished with every thing, which they, who are reputed happy, abound with; and if, without stirring from thence, they should be informed of a certain divine power and majesty, and after some time the earth should open, and they should quit their dark abode to come to us; where they should immediately behold the earth, the seas, the heavens; should consider the vast extent of the clouds, and force of the winds; should see the sun, and observe his grandeur and beauty, and perceive that day is occasioned by the diffusion of his light through the sky; and when night has obscured the earth, they should contemplate the heavens bespangled and adorned with stars; the surprising variety of the moon, in her increase and wane; the rising and setting of all the stars, and the inviolable regularity of their courses; when,' says he, 'they should see these things, they would undoubtedly conclude that there are gods, and that these are their mighty works.' Thus far Aristotle.—Let us imagine also as great darkness as was formerly occasioned by the irruption of the fires of Mount Ætna, which are said to have obscured the adjacent countries for two days, that one man could not know another; but, on the third, when the sun appeared, they seemed to be risen from the dead. Now, if we should be suddenly brought from a state of eternal darkness to see the light, how beautiful would the heavens seem! *But, being daily accustomed to behold them, our minds are not affected, nor troubled to search into the principles of what is always in view; as if the novelty, rather than the importance of things, ought to excite our curiosity.*

Cicero on the Nature of the Gods.

The Mineral Kingdom in rude masses occupies chiefly the interior parts; and is obedient to the laws of attraction or aggregation, by which it increases.

The Vegetable Kingdom possesses the surface of the earth, which it clothes with verdure, imbibes nourishment from the surrounding elements, perspires by its quivering leaves, celebrates its marriages in flowers, and by this intercourse continues its several species; lives, dies, and is regenerated by seeds, preserving the aspect of nature for ever blooming.

It boasts the following tribes, PALMS, kings of the earth, eminent for their prodigious height, remarkable for an unvaried, simple, perennial stem, crowned with a tuft of leaves perpetually green, and bearing the choicest fruit.

* Straight toward heav'n my wond'ring eyes I turn'd,
And gaz'd awhile the ample sky, till rais'd
By quick instinctive motion, up I sprung,
As thitherward endeavouring, and upright
Stood on my feet: about me round I saw
Hill, dale, and shady woods, and sunny plains,
And liquid lapse of murm'ring streams; by these,
Creatures that liv'd and mov'd, and walk'd, or flew,
Birds on the branches warbling; all things smil'd,
With fragrance and with joy my heart o'erflow'd.
Myself I then perus'd, and limb by limb
Survey'd, and sometimes went, and sometimes ran
With supple joints, as lively vigour led:
But who I was, or where, or from what cause,
Knew not: to speak I try'd, and forthwith spake;
My tongue obey'd, and readily could name
Whate'er I saw. ‘ Thou Sun,' said I, ‘ fair light,
‘ And thou, enlighten'd Earth, so fresh and gay,
‘ Ye Hills and Dales, ye Rivers, Woods, and Plains,
‘ And ye that live and move, fair creatures, tell;
‘ Tell, if ye saw, how came I thus, how here?
‘ Not of myself; by some great Maker then,
‘ In goodness and in pow'r pre-eminent;
‘ Tell me, how may I know him, how adore,
‘ From whom I have that thus I move and live,
‘ And feel that I am happier than I know.'

MILTON.

Trees, the nobility of this state, they nearly vie with palms, elevate their heads above the other tribes, whom they protect from storms, and the scorching sun, and maintain on their trunks vegetables, which cannot flourish on the earth, as the misletoe, dodder, and hypocistis.

Some of these put on a quite military appearance, being armed with spines, thorns, and prickles, as the hawthorn, bramble, and holly.

Flowers, the beaux and belles of this empire, surrounding the feet of trees, tender plants of short life, displaying the most shining festive garments.

Grasses, rusticks, the most common, which cover the greatest part of the surface of the earth, constituting the multitude and strength of the vegetable kingdom.

Mosses, an inferior order, occupying the ground relinquished by the former, cherishing in their bosom seeds of the nobler plants.

Ferns, gipsies, covering the most barren lands, and carrying their seeds on their backs.

Fungusses, abjects, plants of the autumn, naked and putrescent.

The Animal Kingdom enjoys the external parts of this world; has for the most part voluntary motion; is impelled by the cravings of want, the delights of love, and the anguish of pain.

The first kingdom, then, comprehends inorganized bodies: the second, organized, but insensible: and the third, organized and sentient beings*.

Each of these Kingdoms rise one above the other. Minerals have no vessels: Vegetables have vessels for the propulsion and formation of nutritive juices: Animals have nutritive vessels, and nerves, a peculiar and distinct system, which is the cause of sensation. And when to feeling is superadded reflection, we behold Man placed at the head of the three Kingdoms of Nature,

> . . . . who, not prone
> And brute, as other creatures, but endu'd
> With sanctity of reason, might erect

---

* This is nearly Linnæus's definition, which is, Lapides crescunt; vegetabilia crescunt et vivunt; animalia crescunt, vivunt, et sentiunt. That is, Minerals have increase without life; vegetables have life, but no sensations; and animals grow, live, and feel.

His stature, and upright with front serene
Govern the rest, self-knowing, and from thence
Magnanimous to correspond with heav'n,
But grateful to acknowledge whence his good
Descends, thither with heart, and voice, and eyes
Directed in devotion, to adore
And worship God supreme, who made him chief
Of all his works.

Milton.

The study of the works of creation then is the exclusive privilege of man,* for he alone, of all created beings,

Looks through nature, up to nature's God.

Pope.

---

* O gracious God! if so many men do not discover THEE in this great spectacle, THOU givest them of all nature, it is not because THOU art far from any of us. Every one of us feels THEE, as it were, with his hand: but the senses and passions they raise, take up all the attention of our minds. Thus, O Lord, thy light shines in darkness; but the darkness is so thick and gloomy, that it does not admit the beams of thy light. Thou appearest every where; and every where unattentive mortals neglect to perceive THEE. All nature proclaims THEE: but she speaks to deaf men, whose deafness proceeds from the noise and clatter they make to stun themselves. Thou art near, and within them, but they are fugitive, and wandering as it were out of themselves. Alas! thy very gifts, which should shew them the hand from whence they flow, amuse them to such a degree, as to hinder them from perceiving it. If THOU wert a barren, impotent, and inanimate body, like a flower, that decays and falls to ruin; a picture, which is but a collection of colours to strike the imagination; or an useless metal that glitters; they would perceive THEE, and fondly ascribe to THEE the power of giving them pleasure; although, in reality, pleasure cannot be felt by inanimate matter, and animation can alone spring from THEE, who art the true source of all life. If therefore THOU wert a lumpish, frail, and inanimate being; a mass without any power; a mere shadow; thy fantastic nature would busy their vanity, and absorb all their mean and brutish thoughts. But because THOU art an UNKNOWN BEING, and SPIRITUAL, they perceive THEE not. The very light, that should light them, strikes them blind; like the rays of the sun, which hinder us from seeing that luminary. In fine, because THOU art too elevated, and too pure in thy nature to affect gross senses, men are become like brutes, and perceive THEE not. Some men have eyes only to see shadows, TRUTH appears a phantom to them. What's nothing, is all; and what is ALL, is nothing. What do I behold in all Nature? GOD every where, and still GOD alone. When I think, O Lord, that all being is an emanation from THEE, THOU exhaustest and swallowest up all my thoughts. I know not what becomes of myself. Whatever is not THOU disappears; and scarce so much of me remains, wherewithal to find myself again. Who sees THEE not, never saw any thing; and who is not sensible of THEE, never was sensible of any thing! He is as if he were not. His whole life is but a dream! He is devoid of comfort! How happy he who searches, sighs, and thirsts after THEE! ' For who is like unto THEE, ' O Lord? My heart melts, and my flesh faints, O God OF MY SOUL, and my ETERNAL WEALTH!'

Fenelon's Demonstration of the Existence of God from a Knowledge of Nature.

BOOK FIRST.

A

BOTANICAL AND PHILOSOPHICAL

ENQUIRY

RESPECTING

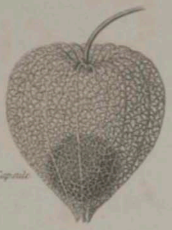
THE SEED VESSEL,

AND

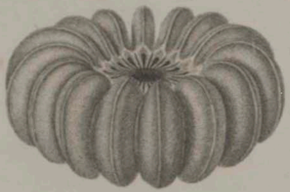
THE SEED.

Vegetable Preparations in the Museum of John Heaviside Esqr. Surgeon to the King F.R.S. &c.

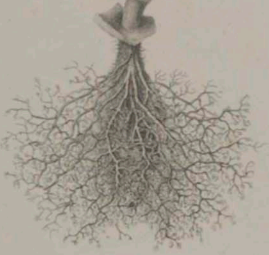
1. Capsule of the Barbadoes Winter-Cherry
dissected by maceration in Water.


The Seed within the Capsule.

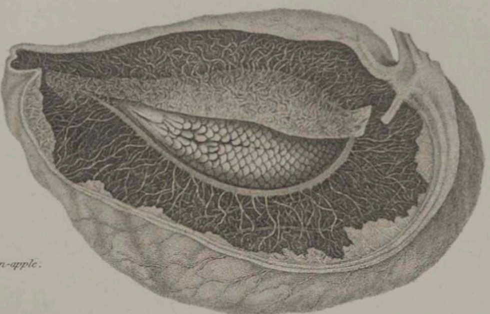
2. Capsule of the Hura crepitans, or Sand-Box
being used for that purpose by the inhabitants of the West Indies.



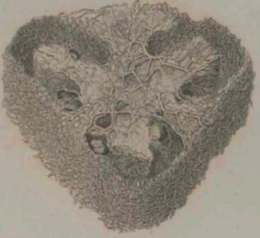
3. The Ligneous Fibres
of a Pear.



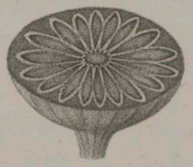
4. Mango
To shew the nutritive Veſsels of the seed as connected with its Pericarp.


The Seeds disposed like Scales, having their own proper covering
in the Center of the true Pericarp, which is a Drupe.

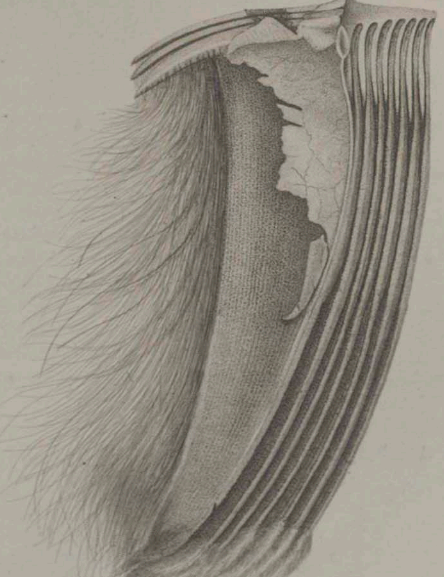
5. The Ligneous Veſsels of the Momordica Luffa, or Balsam-apple.
The Proceſs is natural.


transverse Section
ly of this Pome,
is here represented.

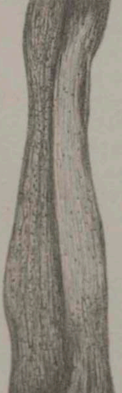
6. A transverse Section of the Sand-Box
To shew its radiated Structure.



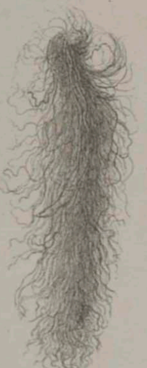
7. Plantain Fruit.
Shewing some of its fine Capillary Veſsels, produced by partial maceration in Water.



8. Part of an Onion injected with Quicksilver
Exhibiting in this state very clearly its fine and numerous Veſsels.



9. The Ligneous Fibres of
The Sugar-Cane.



Henderson del. Warner sculp.

London. Published by Dr. Thornton May 1. 1800.

SECT. III.

THE DIFFERENT KINDS OF SEED-VESSELS.

SYLPHS, as you hover on ethereal wing,
Brood the green children of parturient Spring,
Where in their bursting cells my embryos rest,
I charge you, guard the vegetable nest;
Count with nice eye the myriad seeds, that swell
Each vaulted womb of husk, or pod, or shell;
Feed with sweet juices, clothe with downy hair,
Or hang inshrin'd, their little orbs in air.
DARWIN.

As the chrysalis of the silkworm is enclosed in a golden tomb, so is the seed guarded in a similar manner.

This part is by Botanists called the *Pericarp*[*] (PERICARPIUM), or Seed-vessel.

For the further purpose of the protection of the seed, Nature has sometimes filled this vessel with air, as in the bladder-sena, or with down, as in the bean, and cotton plant.

---

[*] The word *Pericarp* is derived from περι, around, and καρπος, the fruit, being that part which surrounds the seeds, whatever it may be; and from being more commonly a membranous body, hence the English appellation *seed-vessel*, which conveys a more confined notion than the word *Pericarp*, and hence the adoption of the word *Pericarp* in the language of Botany.

Scientific terms are indispensably necessary in the Illustration of Nature, where the objects that present themselves to our consideration are so numerous. The question therefore is not, whether we shall have terms or no, but in what manner they should be constructed so as to answer the great purpose of receiving and communicating knowledge most effectually? Now we have been long in possession of a precise and significant language invented by Linnæus, generally adopted by the learned of every country in Europe, and received in great part into the vernacular tongues of several. Can we do better therefore than to keep as close as possible to this, and to adopt the Linnæan terms themselves, as far as the structure of our language will admit, by Anglicizing his expressions. But when any Latin terms have an appropriate sense in English, it may be better to translate them, than to use what may appear pedantic expressions; so likewise, when the Linnæan terms do not well assimilate to our language, the same rule may be observed, rather than offend the ear. MARTYN.

It must be confessed that a knowledge of Botany has no necessary connexion with the nomenclature; and it is easy to conceive how an intelligent man might be a good botanist, without the

The Pericarp serves also a grander design. It contains the reservoir of nutriment for the embryo-seeds.

PERICARPS are distinguished as follows.

I. A *Capsule* (Capsula), a seed-vessel properly speaking, usually formed of several external pieces, called *valves* (valvulæ), which are joined together by their *sutures*, or borders, but cleave, or separate, at the time of maturity, when the capsule becomes dry and membranaceous, for the purpose of liberating the seeds it contains.

Upon its opening you discover in the centre the *Column* (Columna), whence arise the *Partitions* (Dissepimenta), forming the *Cells* (Loculamenta), which contain the seeds.*

The capsule usually opens at top; and we may here remark a wise contrivance in Nature. However inclined the flower, as in the crown imperial, superb lily, and poppy, the seed-vessels, as they advance towards maturity, become rigidly erect.

In the poppy, the capsule is a kind of vase, with a cover like a parapluie, reflected over the unripe seeds, which rises as they become mature, discovering the apertures of the capsule for the escape of the seeds; there being one opening to each cell.

It sometimes opens transversely, as in anagallis; at the bottom, as in triglochin; but usually longitudinally, as in the horse-chesnut.

In some plants the capsule is found to be very pulpy, although these, when ripe, preserve their distinctive character, and are sometimes of so elastic a nature, that the seeds are darted from them with great force and velocity.

If you press betwixt your fingers and thumb the capsule of the balsam,

---

knowledge of the meaning of any one precise term. But such a man could not become a writer, nor could he derive advantage from the labours of others. The question then is, whether three hundred years of study and observation should be lost to Botany, whether three hundred volumes of figures and descriptions should be thrown into the fire, whether the knowledge acquired by all the learned, who have consecrated their purse, their life, their time, to distant, expensive, painful, and dangerous expeditions, should be useless to their successors, and whether every one setting out from nothing, could arrive by himself at the same knowledge, that a long series of inquiry and study has spread over the mass of mankind? If not, and if the most lovely part of natural history merit the attention of the curious, let them tell me how we shall manage to make use of the knowledge heretofore acquired, if we do not begin by learning the language of the writers, and knowing to what objects the names employed by them belong. To admit therefore the study of botany, and to reject that of the nomenclature, is a most absurd contradiction. Rousseau.

* Vide Plate III. The different kinds of Seed-vessels, and their Anatomy.

the impatiens noli me tangere, the seeds will be immediately rejected with violence. The same is still more conspicuous in the spirting cucumber, where the experiment is attended with some hazard to the sight. The seeds fly from eight to ten feet. If you press the humble sorrel, the oxalis corniculata, with your hand, you will be surprised to see the seeds immediately become scattered in every direction, more than a foot's distance from the plant.

The ligneous vessels of the capsule are finely displayed in a preparation of the thorn-apple, datura stramonium, as made by maceration in water, when the skin peeling off, and the parenchymatous part dissolving into pulp, leaves the ligneous and fibrous parts entire. Beautiful examples of these are likewise to be seen in the first private cabinet perhaps in Europe for the illustration of subjects of anatomy; I mean that of Mr. Heaviside, Surgeon to his Majesty, who, with his accustomed liberality and politeness, has offered whatever might tend to assist this work.

II. A *Silique*[*] (SILIQUA) is a pod in which the seeds are alternately fixed to either suture, or union of the valves, or shells, the seeds hanging by a thread, or peduncle, to the two sutures. When the pod is broader than long, it is called then a *Silicle* (SILICULA), the diminutive of the last, from the seed-vessel being usually much smaller than in the other.

III. A *Legume*[†] (LEGUMEN), a species of seed-vessel, enclosing a number of seeds that are fastened along one suture only.

IV. A *Follicle*[‡] (FOLLICULUS), a thin membranaceous seed-vessel, of one valve, opening longitudinally, or on one side, and having no apparent suture for fastening, or attaching the seeds within it.

---

[*] Siliqua is derived from *silo*, a nose turned up, from the curve in this kind of seed-vessel. When *antique*, *critique*, and *burlesque* were first introduced into our language, they were written *antick*, *critick*, and *burlesk:* had this orthography obtained, we should have put this pericarp *Silick*, and thus have avoided the French termination. I shall not contend with any one who would retain the Latin final; nor with any other who would appropriate the English term *pod* to this, exclusive of the legume. MARTYN.

[†] *Pod* is used for legume, silique, and silicle, indifferently; but they are so distinct, as is seen by the attachment of the seeds, that they ought not to have the same appellation. It seems best, therefore, to Anglicise the Latin terms; and with respect to this term, there is no danger of offending the English ear. MARTYN.

The word *Legume* is derived from legere, to collect, because these are usually collected by the hand.

[‡] Diminutive from follis, a pair of bellows, the *Follicle* being usually swelled out with air, as in asclepias.

V. A *Drupe*[*] (Drupa), a pulpy body, without valves, enclosing a nut or stone, with a kernel.

VI. A *Nut*[†] (Nux), a hard ligneous shell, without a pulpy covering.

VII. A *Pome*[‡] (Pomum), a species of seed-vessel, pulpy, not enclosing a stone, in the midst of which is found a membranaceous substance, forming cells, or cavities, for containing the seeds.

VIII. A *Berry*[§] (Bacca), a pulpy seed-vessel, enclosing numerous seeds, dispersed throughout the pulp.

IX. A *Strobile*[||] (Strobilus), a species of seed-vessel formed of woody scales, which embrace the seeds within their bosom. No force can draw these asunder; yet, immersed in warm water, or placed near the fire, they open most freely of themselves, exhibiting the contained seeds.

We have now enumerated the several distinct forms of Pericarps, under which all others must arrange themselves. However diversified the appearances of each may be, yet must they all fall under one of these nine general heads. The utility of such distinctions we shall see hereafter.

[*] From δρυς, a tree, and πεπτειν to concoct, this species of pericarp ripening on the tree before it falls: the cherry, plum, and olive, are examples of this. Miller translates in consequence, Drupa, a *Plum*; but, according to Linnæus, sometimes this pericarp is dry as the almond, which perhaps would better follow the ensign of the nut, which I have ventured to consider as a seed having a pericarp. Vide note †.

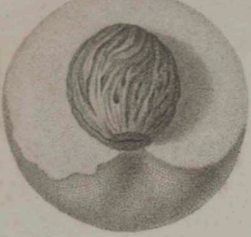
[†] Nux, a nut, is defined by Linnæus to be a seed covered with a shell: this shell I have considered as a distinct species of pericarp, containing the nucleus, or seed, and with what propriety I leave to the candid reader.

[‡] From Pomum, an apple, as it includes all the moist fruits which have the seeds lodged in a core. It cannot, however, be translated an *Apple*, as Miller has done, since it comprehends also the gourd, cucumber, &c. and the English term would be taken in too limited a sense.

[§] It is distinguished from the former, the pome, chiefly by having no apparent partitions for the seeds.

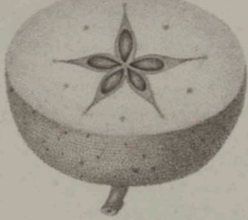
[||] This term, derived from ϛροϐιλος, an artichoke, from the resemblance which this kind of seed-vessel has to its imbricated leaves, includes not only the cone of former writers, but also some other pericarps, which recede considerably in structure from that sort of pericarp, as the magnolia. To translate, as Millar has done, Strobilus a *Cone*, is improper, as giving a false general conception. Martyn.

The different Kinds of Pericarps.

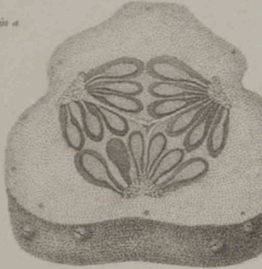


1. A Drupe.
A Stone surrounded by Pulp.
Peach.

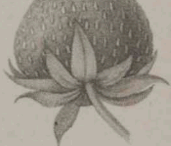
2. Pomes.
Radiated Cells in a
pulpy body.



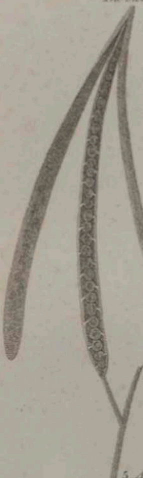
Apple.



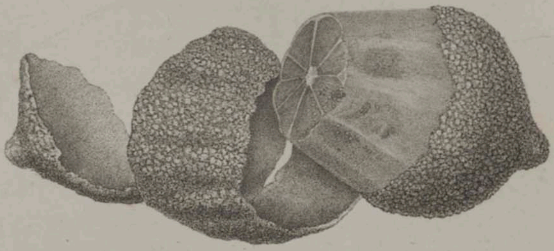
Cucumber.



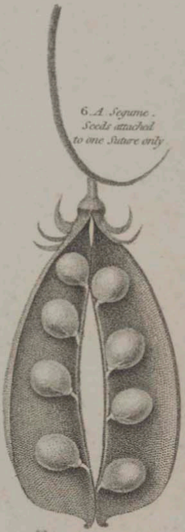
3. A Berry
Seeds dispersed in a pulpy body
Strawberry.



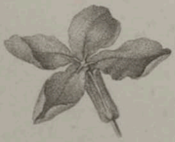
4. A Silique.
Seeds attached to two opposite Sutures.
Pericarp longer than broad.
The Stock.



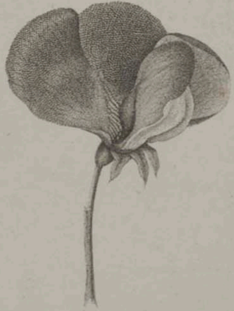
Lemon.



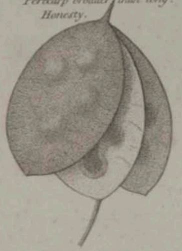
6. A Segume.
Seeds attached
to one Suture only



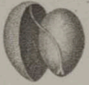
A Cruciform Flower.



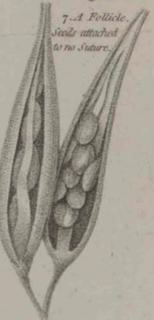
A Papilionaceous Flower.



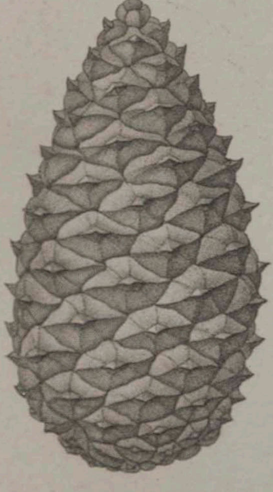
5. A Silicle.
Seeds attached as in the Selique
Pericarp broader than long.
Honesty.



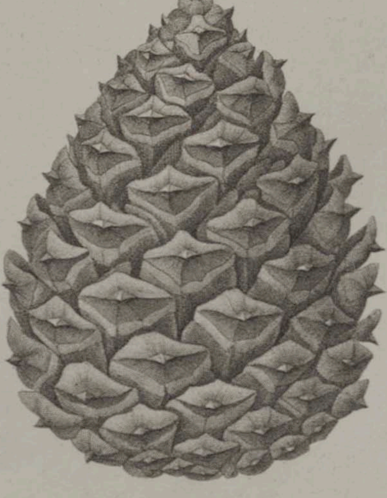
8. A Nut
A shell not surrounded by pulp.



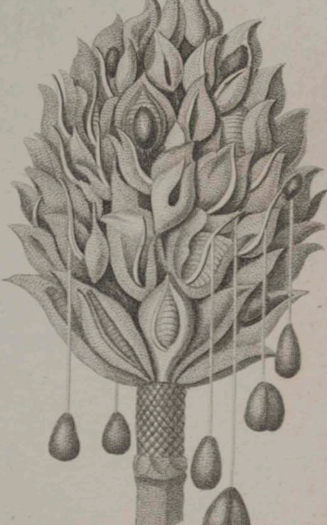
7. A Follicle.
Seeds attached
to no Suture.



A Pine shut.



9. Strobiles.
Seeds defended by Scales
A Pine open.



Pericarp of the large-flowering Magnolia.
A Species of Strobile.

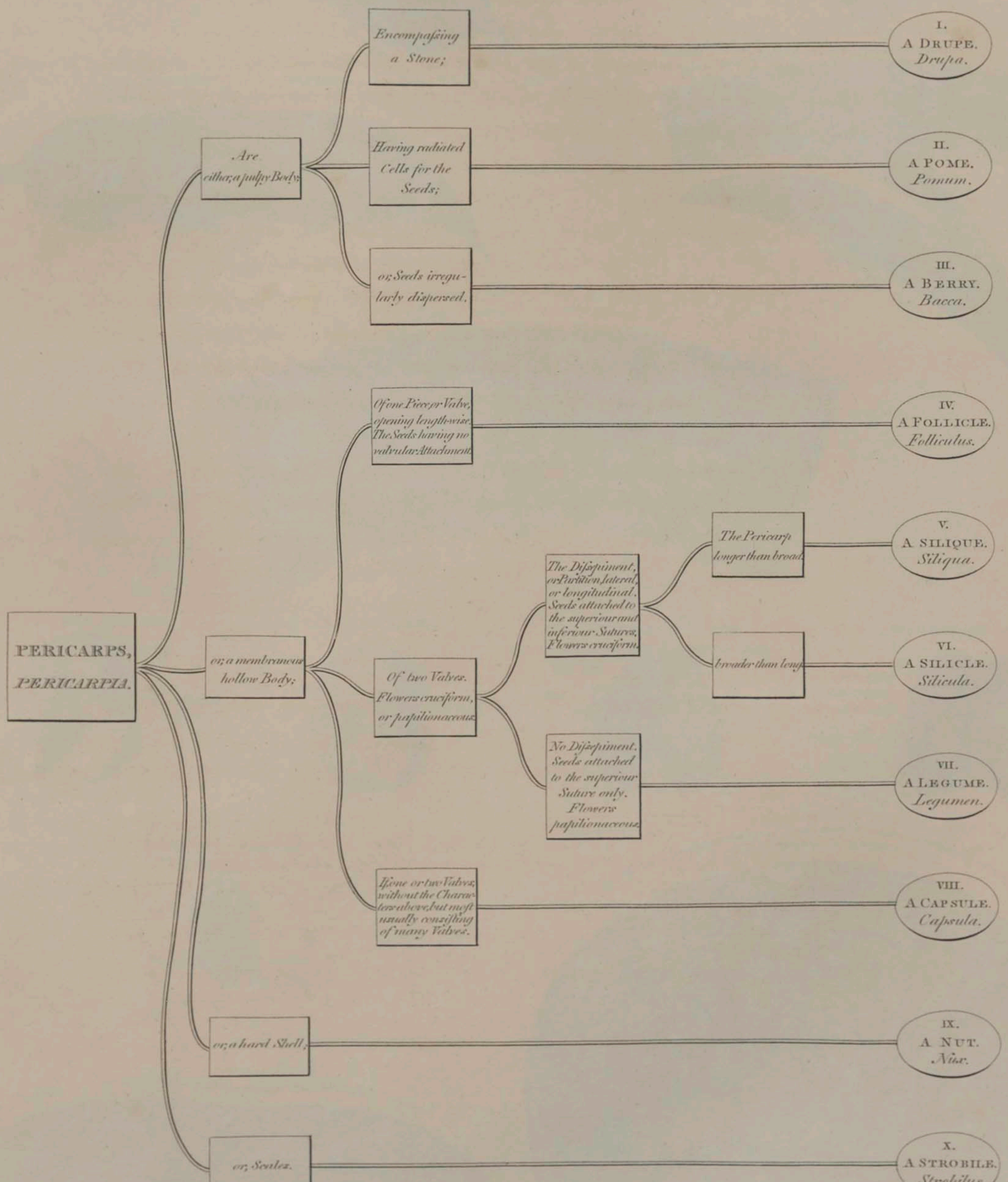
NB. The Capsule is omitted here having been before represented in the Plate of the Anatomy of the Pericarp, facing page 18, where the Thorn-apple furnished an excellent example.

Henderson del.

ANALYSIS,

OF

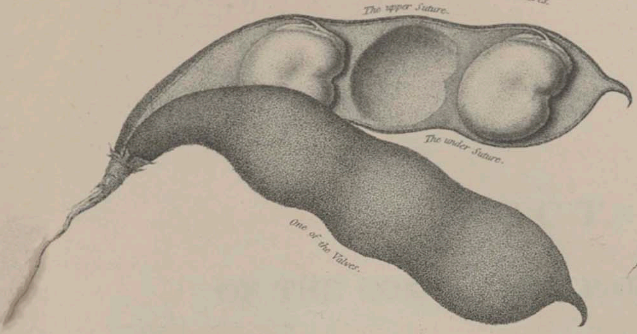
Division of Pericarps into their Several Kinds.


PERICARPS,
PERICARPIA.
Are either, a pulpy Body;
Encompaſsing a Stone;
Having radiated Cells for the Seeds;
or, Seeds irregularly dispersed.
or, a membranous hollow Body;
Of one Piece or Valve, opening lengthwise. The Seeds having no valvular Attachment.
Of two Valves. Flowers cruciform, or papilionaceous.
The Diſsepiment, or Partition lateral, or longitudinal. Seeds attached to the superiour and inferiour Sutures. Flowers cruciform.
The Pericarp longer than broad.
broader than long.
No Diſsepiment. Seeds attached to the superiour Suture only. Flowers papilionaceous.
If one or two Valves, without the Character above, but moſt usually consiſting of many Valves.
or, a hard Shell;
or, Scales.
I. A DRUPE. Drupa.
II. A POME. Pomum.
III. A BERRY. Bacca.
IV. A FOLLICLE. Folliculus.
V. A SILIQUE. Siliqua.
VI. A SILICLE. Silicula.
VII. A LEGUME. Legumen.
VIII. A CAPSULE. Capsula.
IX. A NUT. Nux.
X. A STROBILE. Strobilus.

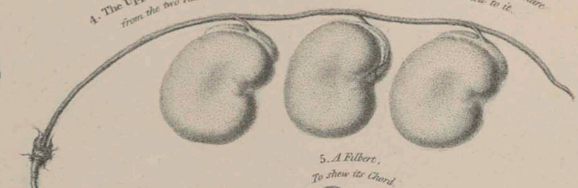
W^m J Thornton inv^t
London: Publiſhed Augt 2 1799 for Dr Thornton
J. Girtin sc^t

Anatomy of the Bean.

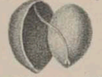
1. **The Legume**, *or* **Bean-pod**, *filled with Down.*
The Beans fixed alternate in the Cavities of the Valves.


The upper Suture.
The under Suture.
One of the Valves.

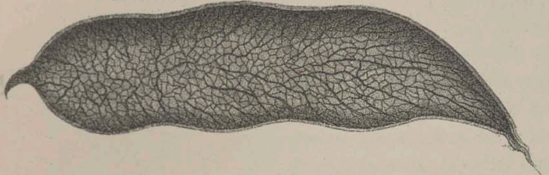
4. **The Upper Suture**, *(which in the preceeding figure readily divided into two,) separated entire from the two Valves, to shew, how the chords of the three Beans are attached to it.*



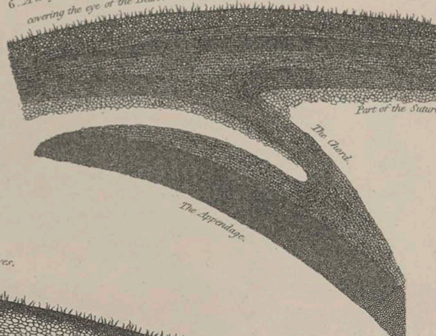
5. *A Filbert,*
To shew its Chord.



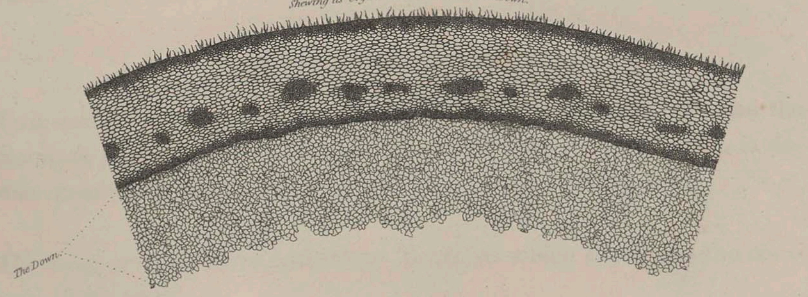
2. *A Valve, stript of its Down, shewing the Ramification, and Termination of its Veſsels, in the two Sutures.*



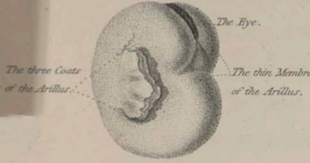
6. *A longitudinal transparent Section of the* **Suture**, *and the* **Chord**, *with its* **Appendage**, *covering the eye of the Bean, as seen through the Microscope.*


Part of the Suture.
The Chord.
The Appendage.

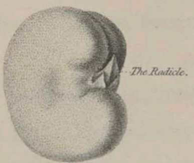
3. *A transparent transverse Section of one of the Valves, Shewing its Organization, and that of the Down.*



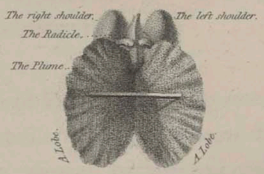
7. *The Bean covered with its Arillus, or Husk.*


The Eye.
The three Coats of the Arillus.
The thin Membrane of the Arillus.

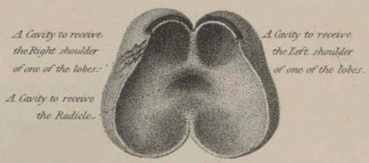
8. *The Bean stript of its Arillus.*


The Radicle.

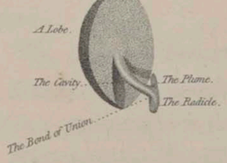
9. *The Bean opened, to shew the Plantule.*


The right shoulder.
The left shoulder.
The Radicle.
The Plume.
A Lobe.
A Lobe.

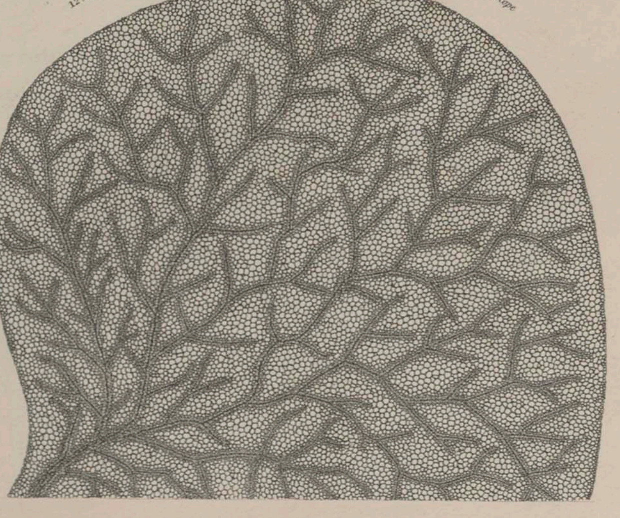
10. *An Internal View of the Arillus.*


A Cavity to receive the Right shoulder of one of the lobes.
A Cavity to receive the Left shoulder of one of the lobes.
A Cavity to receive the Radicle.

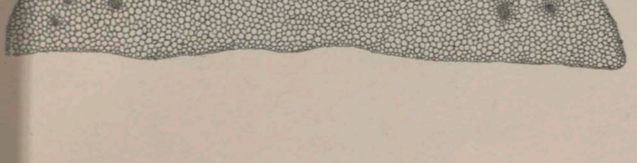
11. *One of the Lobes of an Acorn, To shew the Cavity, containing the Bond of Union betwixt the Lobes and Plantule.*


A Lobe.
The Cavity.
The Plume.
The Radicle.
The Bond of Union.

12. *Half of a Longitudinal transparent Section of one of the Lobes, as seen through the Microscope To shew the Veſsels converging to one Point.*



13. *A transverse transparent Section of one of the Lobes, as seen through the Microscope.*



Warner delin. et sculp.

London. Published by Dr. Thornton. Novr. 1. 1799.

SECT. V.

OF THE COMPONENT PARTS OF THE SEED.

> .... In thy book
> Was the fair model of each structure drawn,
> Where every part, in just connexion join'd,
> Composed and perfected th' harmonious piece,
> Ere the dim speck of being learnt to stretch
> Its ductile form, or entity had known
> To range and wanton in an ampler space.
>
> Pitt.

The seed is defined by Linnæus to be the end of fructification, and the beginning of a new plant; or that portion of the maternal plant which is deciduous, containing within itself the rudiments of a new vegetable.

There are several Parts noticed by Botanists which enter into the composition of the seed.

As the bean exhibits these in the clearest manner, let us examine one of them; for example, the common broad Windsor-Bean.

The pod of the bean, as you have before learnt, is a *Legume,* composed of two *valves,* which were the pieces, or shells, which the bean divides into, filled with the softest *down,* which appears, viewed by the microscope, to be a cluster of blebs, or bladders.*

When the bean-pod opens naturally, it splits from its *under border,* or suture.

The *upper suture,* which readily divides into two parts, is an assemblage of *filaments,* or vessels, to which the beans themselves are attached by a slender *peduncle,* or thread.

The *valves,* if suffered to remain a few days in the house, especially if handled, shew a beautiful organization.

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* Vide the Plates of the Anatomy of the Bean.

The *vessels* turn black, and disclose their distribution throughout the valves, terminating in the sutures for the nourishment of the seeds.

These vessels may be also easily seen with the naked eye by holding the shell up before the light.

The *peduncle,* or chord, rises slender, but ends in a *broad expansion,* very succulent at first, which, as it becomes useless, withers, disclosing the *hilum,* or eye of the bean.

In the centre of the hilum runs a *vessel,* which appears to divide it in two, at the extremity of which is an *aperture.*

This *aperture,* or foramen, was discovered by Grew an hundred years ago. It is not, says he, a hole casually made, or arising from the separation of the stalk, but designed for a special purpose.

It is observable not only in the common bean, and in the scarlet bean very plainly, but is also to be found in pease, lupins, lentils, and other pulse, and many seeds not reckoned of this kind, as that of fœnugreek, goats-rue, and others, in many of which it is so small, as scarcely without the help of glasses to be discerned, and in some not without cutting off a part of the outer cover of the seed.

This pierces the *arillus,* or, what is vulgarly called, the husk of the bean.

The *arillus* may be separated into three *layers,* and has its form exactly adapted to that of the bean.

These harmonies have often called forth the admiration of the wise intentions of the Author of the World, and proved his agency, nor ought they to be slightly passed over by us his creatures, whose highest prerogative is that of contemplating the wonders of creation, and adoring its Gracious Author.

But, before we consider the form of the arillus, let us first contemplate the seed it is destined to cover.

The first thing that naturally strikes the observer, is a small projecting point, like the beak of a bird, called by Botanists from that resemblance *rostellum,*[*] opposed to which is a tender *projection* enclosed within the lobes, or body of the bean.

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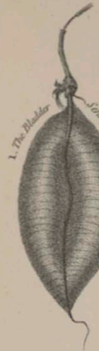
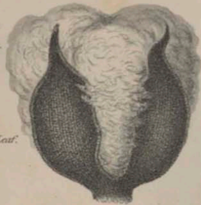
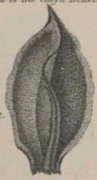
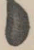
[*] From rostellum, a beak.

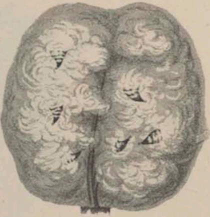
Anatomy of the Pericarp.

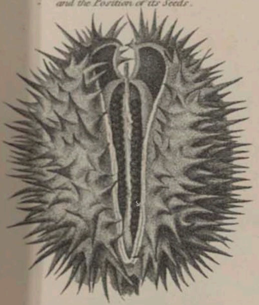

1. The Bladder Sena Pod.

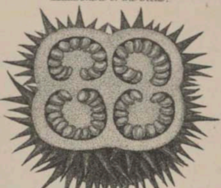

2. The Pericarp of the Cotton Plant.
The Cotton enclosed within three Calyx Leaves.
A Calyx Leaf.

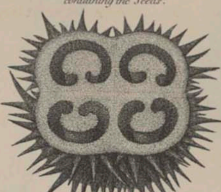

3. An Internal View of one of the Calyx Leaves.
Its Diſsepament.

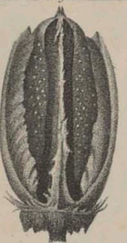

4. The Seed

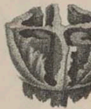

5. The Seeds as enclosed in the Cotton.

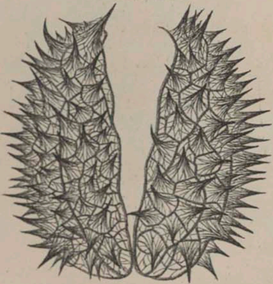

6. Pericarp of the Thorn Apple Shewing its Four Valves, and the Position of its Seeds.

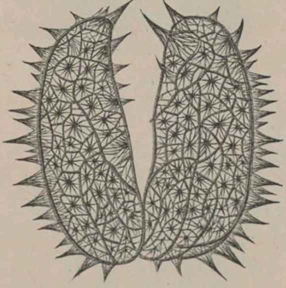

7. A transverse Section of Dº To shew the Column, and Attachment of the Seeds.

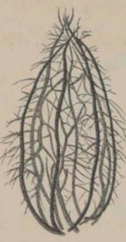

8. Dº more distinctly to shew The Column, and the Cells containing the Seeds.

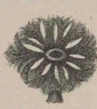

9. The Column
The white Dots shew the original Attachment of the Seeds.

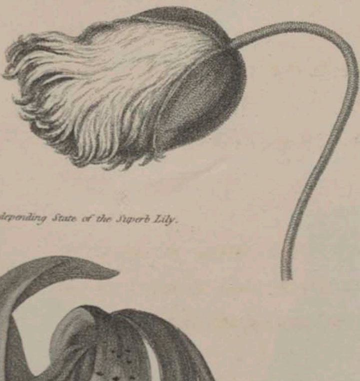

10. A transverse Section of Dº The better to represent Its true Form.

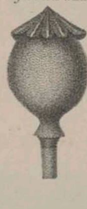

11. An External View of the Ligneous Veſsels of two of its Valves.

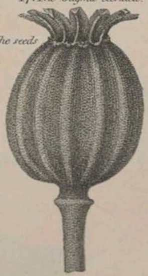

12. An Internal View of the Ligneous Veſsels of its other two Valves.

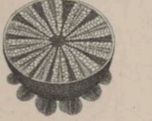

13. The Ligneous Veſsels of the Column.

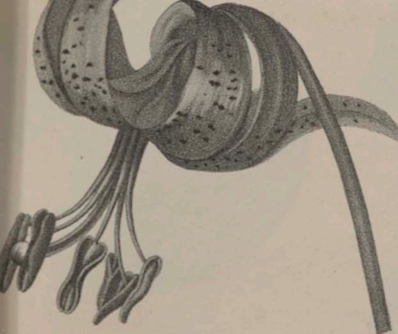

14. The Basis of the Column.

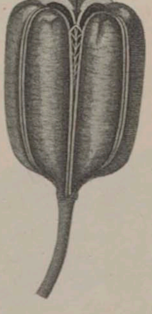

15. The Poppy as it depends.

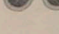

16. The Pericarp upright
The Stigma like a Parapluis.

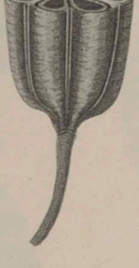

17. The Stigma elevated.
The openings to let out the seeds

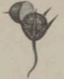

18. A Transverse Section of Dº To shew the Divisions, and Seeds.

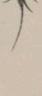

19. The depending State of the Superb Lily.


20. The Pericarp splitting longitudinally Into three Valves from above.


21. The Seeds.


22. A Transverse Section of Dº To shew the Position of the Seeds.

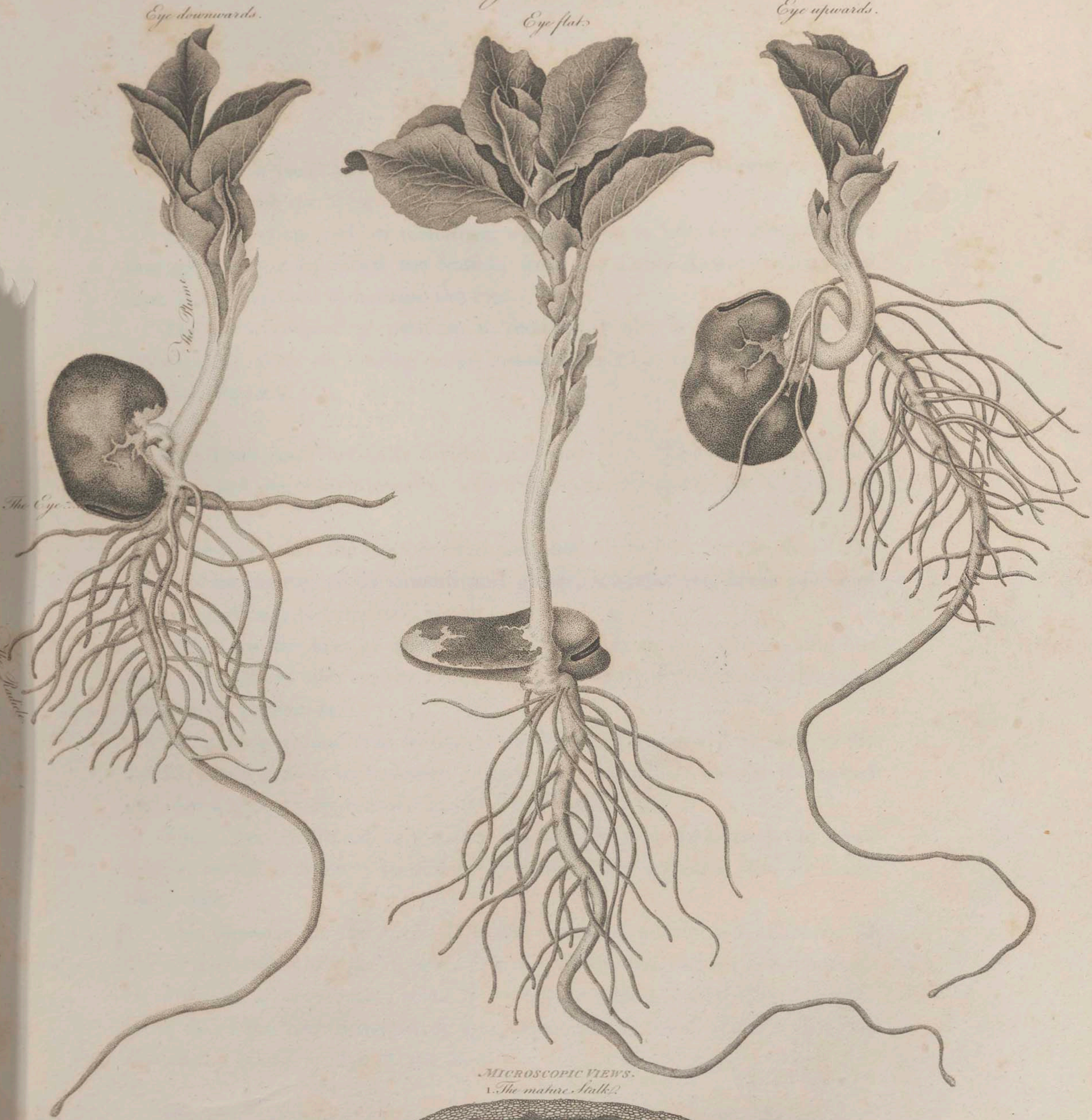

23. The Pericarp of the Anagallis opening laterally.


24. Dº of the Sagitaria opening from below.

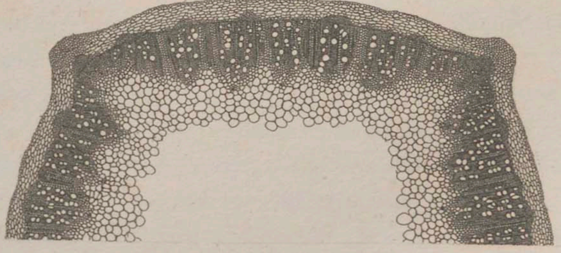
Henderson del. Warner sculp.

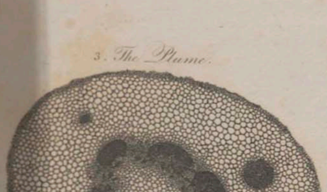
London, Published by Dr. Thornton, Novr. 1. 1799.

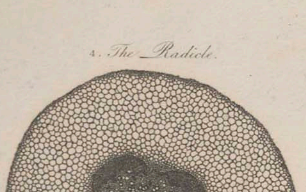
Anatomy of the Bean.

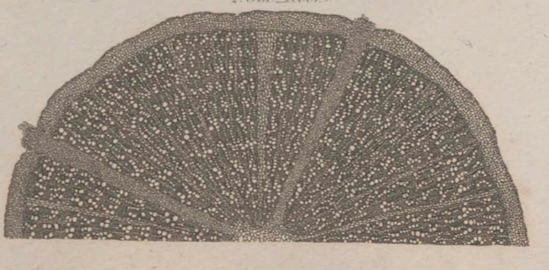

Eye downwards.
Eye flat.
Eye upwards.
The Plume.
The Eye.
The Radicle.

MICROSCOPIC VIEWS.


1. The mature Stalk.


3. The Plume.


4. The Radicle.


2. The Root.

Henderson delt.

London Published November 1. 1799 by Dr. T

Warner sculpt.

These two parts have been styled in the language of Botany *corculum,* the heart of the seed.

The projecting part, or rostellum, when it shoots into the ground in its first growth is then called the *radicle,* from the Latin RADICULA, a small root, being destined to become the root.

The other projecting part, as it mounts in air, is called the *plume* (PLUMULA), from its bearing some resemblance to a feather, the Latin for which is PLUMA.

The bean itself naturally divides into *two lobes* (LOBULI), convex exteriorly, and concave internally, which are joined together in a dove-tail manner.

If you examine the *surface* of these lobes, there will not be found the smallest inequality, all is smooth and glossy, whereas the finest polish of human ingenuity is extremely rough.

Only view the best wrought needle, it presents to your eye nothing but huge inequalities, whereas the works of the Almighty ever manifest the most astonishing perfection.

By making a transverse section along the lobes, there will be seen on the surface *small vessels* interspersed among the blebs, which, even to the naked eye, has a greener appearance than the other parts.

These were rendered very visible by Bonnet, who immersed the lobes in ink, and a transverse section being made, they appeared like so many black dots.

This organization, however, is better shewn by a longitudinal section of one of the lobes, when the *ligneous vessels* will be observed to pass in a regular direction, all terminating towards the *plume,* which is affixed to each lobe, lying under the two *shoulders,* or projections of the bean, above which was situate the hilum, or eye of the bean.

We now are able to comprehend how excellently the arillus is contrived for the protection, and containing of the seeds.

The *arillus,* viewed internally, has *two cavities* for the reception of the *two shoulders* of the bean just before explained; and under these, exactly in the centre, is another and deeper *cavity* for the reception of the *rostellum*; and, if we return from surveying the internal structure to the external, we shall readily perceive, that that part of the arillus which corresponds to the *rostellum* is almost a *mere membrane,* at the apex of which was the *aperture* before noticed, the utility of which structure will afterwards be explained.

ANALYSIS.

SEEDS are therefore composed of

I. The HUSK, or *Arillus.*

II. The CHORD, or *Chorda.*

III. The EYE, or *Hilum.*

IV. The PLANTULE, or *Corculum,* made up of the
  1. *Radicle,* and
  2. *Plume*; and lastly,

V. The LOBULI, or *Lobes.*

PHILOSOPHICAL INQUIRIES.

SECT. VI.

I. OF THE USES OF THE SEVERAL PARTS OF THE SEED.

Come, ye soft Sylphs! who sport on Latian land;
Come, sweet lip'd Zephyr, and Favonius bland!
Teach the fine seed, replete with life, to shoot
On Earth's cold bosom its descending root;
With pith elastic stretch its rising stem,
Part the twin lobes, and fan th' aspiring gem.

Darwin.

The Pericarp is usually represented by Botanists as solely destined for protection, whereas its chief and primary use is the *nourishment* of the young seeds. Hence the Pericarp, or column in its centre, serves the office of placenta to the embryos, the seeds being, as we saw before, attached to them by a *thread,* or *pedicel,* which bears an analogy to the umbilical chord of the fœtus, so little do even the subordinate parts of creation lose by comparison with the higher.

This *chord* is very visible in the bean and nut, and indeed exists in every plant; but, as the embryos increase in growth, this attachment is dissolved, and *vegetable parturition* may now be said to be performed: and as the chord becomes in the child a ligament,* so the pod assumes a new appearance, and becomes a *dry husk,* and its valves separating, the seeds are dropped from within its bosom, which may not be unaptly styled a *second birth.*

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* It becomes the suspensory ligament of the liver.

An objection may perhaps be started to this doctrine from the consideration of succulent and stony fruits; but these, in their early stage, have the same organization as Pericarps.

We have an example of this in the pear and the mango;* and it may be observed, that the deposit of hard, woody, or stony particles, does not take place till a considerable time after the full formation of the embryo. Young filberts, or the walnuts which we use for pickles, are also very familiar examples of the soft state of the early shell.

The woody shell may therefore be considered as a true pericarp;§ and, as the manner in which the kernel is able to escape from its enclosure is a matter of no small wonder to the contemplators of nature, it certainly deserves our present consideration.

For the escape of the seed, the hard shell, acted on by heat and moisture, and the rarefaction of the air within, and force of the struggling embryos, endeavouring " to burst their cearments," opens " its marble jaws," and this with a facility exceeding common apprehension.

For this purpose shells are like pericarps, which first seem of one valve, one entire piece, scarcely shewing even a line of separation, and then divide, as the occasion requires, into several different compartments, or pieces, but more usually into two, which might be conjectured from observing the natural division that takes place in walnuts, apricots, and other stone fruits.

Where there is neither pericarp, nor shell, for some plants are found actually to bear *naked seeds* (SEMINA NUDA), the *calyx*‡ then serves the office of pericarp, and increases with the growth of the embryos, and so involves them, as not unfrequently to be mistaken for real pericarps.

The ramifications of the *vessels* in the leaflets of the calyx may be made apparent by maceration in water, as the skeleton of other leaves are produced; and their conjunction with the receptacle of the seed is then very evident.

When the seed has been liberated from its foldage, water enters by the *aperture*, or foramen, before mentioned, and insinuates itself between the

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* Vide the Plate representing some preparations in the superb collection of Mr. Heaviside.

§ Vide note †, page 20.

‡ The Calyx is reckoned one of the parts of fructification, and will be explained hereafter. It has a double office, the protection first of the flower, next of the fruit, and it sometimes, as shewn above, performs the office of placenta, in lieu of the Pericarp.

lobes, and the *arillus*, which it raises up, and becoming absorbed, the first growth is now commenced.

To prove this use of the *aperture*, the Baron de Gleichen made the following experiment. He covered the apertures of several beans with varnish. After it was perfectly hardened, he put these beans, and those which were not so treated, into water, in which carmine had been dissolved.

The first remained four or five days without shewing the smallest change, nor was there any redness found under the arillus.

But it was quite different with the others that were not varnished.

They were full of the red liquid, and began to vegetate before the third day.

Grew, who observed this *aperture* in all seeds which have hard skins above an hundred years ago, entertained the following curious opinion respecting its *use*, as well as that of the *arillus*. His words are,

" First of all, the bean being enfolded round with its *three coats*, the sap wherewith it is fed must of necessity pass through these, by which means it is not only in a proportionate quantity, and by degrees, but also of a purer body, and possibly not without some vegetable infusion, which is transmitted to the bean. Whereas, were the bean naked, the sap must needs be not only overcopious, but crude and immature, as not being filtered through so fine a cotton as the coats must be."

" And, as they have the use of a filter for the sap to pass through, so they have the property of a containing vessel, being alike accommodated to the securer fermentation thereof, as barrels are to any fermenting liquor."

" And, as fermentation is promoted by some aperture in the vessel, so have we the *foramen* in the upper coat also contrived; that if these should be in need of some more airy particles to excite the fermentation, through this they might obtain their entry; or, on the contrary, should there be any such particles, or steams, as might damp the genuine proceeding thereof, through this again they may have easy issue; or, if by being overcopious, they should become too high a ferment, and prevent those slow and progressive degrees, as are necessary to a due vegetation. The said aperture being that, as a common passport here to the sap, with what we call the *vent hole* of the barrel is to the new tunned liquor."

The chief design of the *arillus*, however, appears to be, not the filtering of the water, for the water enters by the aperture; or, if the arillus be extremely thin, pervades it; but a wise protection for the seed, as the shell of an egg defends the young chick; and, being indigestible, the seed passes uninjured through the bodies of animals when swallowed whole;[*] and, being of an oleagenous nature, it prevents a too copious influx of moisture from coming to the lobes, which are sure to rot them. This part, therefore, is not so essential to growth as was supposed by Grew, several seeds being known to germinate equally well when divested of their arillus, if placed in a soil that is not too moist.

We come now to the consideration of the *lobes*, improperly called *cotyledons* by Linnæus, from the analogy which he supposed this part bore to the COTYLEDONES in brutes.[†]

We will endeavour to shew that it bears a much stronger affinity with the MAMMÆ, or *breasts*, indulging that freedom of inquiry for which the present age is so remarkable.

Formerly investigation was silenced by authority. The Ipse Dixit of a great name was received with oracular veneration. The mind yielded passive obedience, and all the free scope of the understanding was shackled by a blind admiration.

But, at the same time, whilst we presume to differ with so great a genius, we do it with all due deference, not less admiring the transcendent talents of the great reformer of Botany, than the astronomer who depicts a few spots in the sun can revere the less that bright luminary.

The Author of Nature, with equal eye, watches over the infancy of the whole creation. The animal enjoys the milky fountain of its mother. The infant vegetable lives upon a similar fluid, though differently supplied.

For its use the *lobes*, which serve the office of *breasts*, form *a kind of milk*, which is conveyed to the plantule by means of the returning vessels, which descend to it from the substance of the lobes.

It is curious to observe, that even the mucilage of almonds has obtained the appellation of milk of almonds.

The liquor procured from barley, when it has germinated, is called sweet-wort, and new milk, we know, has the same soft and sweet taste.

Without this supply of balmy liquor, the plantule must inevitably have perished; its roots being then too small to absorb a sufficient quantity of bland food, and its organs too weak to assimilate it into nourishment.

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[*] Vide Sect. VIII. on the propagation of plants.

[†] The cotyledones in brutes are analogous to the placenta in us, being several small placentulæ, to which the several fœtuses are attached.

Water replete with air passes through the pores of the earth, and in this manner supplies with oxygen* those lobes which lie concealed within the ground, as the bean, &c.

Most seeds, however, rise above the surface, expand their lobes to the zephyrs, and immediately, as in the lupin, they change from a pale yellow to a bright green.

So attentive is Nature to her infant progeny, that, where the lobes are small, *seminal leaves* issue from the seed upon its first expansion: and these have been called *dissimilar leaves*, from being totally unlike the leaves, which are afterwards protruded, for they possess a consistency approaching the nature of lobes, and are never found to have their borders serrated, like other leaves.

When prepared and examined by the microscope their anatomy very nearly resembles that of the lobes.

The origin of these seed-leaves did not indeed escape that great observer of nature, our countryman Grew, who remarks, " that the dissimilar leaves for the most part are two, which first spring up, and are of a different shape from those that follow, being the very lobes of the seed itself, divided, expanded, and then advanced."

" The impediment of our comprehension thereof are the colour, size, and shape of the dissimilar leaves. Notwithstanding that, they are nothing else but the *main body* of the seed, which how I came first to know was thus:"

" First, I observed in general, that the *dissimilar leaves* were never jagged, but even edged; and seeing the even verges of the lobes of the seed hereto respondent, I was induced to think, that those so resembling might prove the same."

" Now, descending to particular seeds, I observed, first of the lupin, that, as to its colour, advancing above the ground, as it useth to do, it was always changed into a perfect green: and why might not the same, by parity of reason, be inferred of other seeds?"

" Secondly of the cucumber, whose seed, as to its colour, often appearing above ground, in its primitive white, from white it turns to yellow, and from yellow to green, the proper colour of the seminal leaf."

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* The combination of air with water is very distinctly seen by means of the air-pump. If a glass containing rain water be exposed under the receiver, it will very soon shew on its surface air-bubbles; and this appearance will continue a long while, until all the bubbles burst, and the whole air be completely disengaged.

“ That, as to its size, it grew but little bigger than when it first shot, whence, as I discerned the augmentation very little, we here have actually the two lobes.”

“ But whereas the lobes of the seed are narrow, short, and thick, how then come the dissimilar leaves to be in comparison so exceeding broad, or long and thin?”

“ The question is answered thus: the dissimilar leaves are thin, because they are very broad or long, as we see many things how much they are extended in length or breadth, so much they lose in depth, which is, what here happens to the now effoliated lobes.”

“ This in some dissimilar leaves is very remarkable, as in those of lettuce, thorn-apple, and others, whose seeds although small, yet the lobes of these seeds growing up into dissimilar leaves, are extended an inch, and sometimes more, in length.”

“ The original of the dissimilar leaves thus known, we understand,” “ Why some plants have none, because the seed either riseth not, as with beans, corn, &c. Or upon rising, the lobes are little altered, as lupins pease, &c.”

“ Why though the proper leaves are often indented round, the dissimilar, like the lobes, are even-edged. Why though the proper leaves are often hairy, yet these are ever smooth.”

“ Why some have more dissimilar leaves than two, as cresses, which have six, as the ingenious Mr. Sharrock has also remarked. The reason whereof is, because the main body of the seed is not divided into two, but six distinct lobes, as I have often counted.”

“ But for the most part the seed is divided into two lobes, of an homogeneous nature, plainly distinguished in most kernels, as the walnut, and not with much difficulty in some of the lesser seeds, as in that of the viola lunaria, scabious, doves-foot, &c. if slipt out of their covers before they are full ripe.”

It is thus with the parent animal, who possesses two or more dugs *. These serve, however, a still more important office in the vegetable world.

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* The number of dugs is always proportioned by Nature to the offspring to be produced. In a litter of pigs, it may be remarked, that each pig always goes to its own dug, and never usurps that of another. Children when first born ſhew the same partiality for one breast.

The breasts serve also the office of a warm and soft pillow to cheriſh the babe. How strong and tender also is maternal affection! But faſhion has, alas! perverted this wise ordination, and children now, as soon as they come into the world, are committed to *hirelings*.

Bonnet, in order to assure himself of the utility of these parts, made the following experiments.

" I sowed," says this celebrated naturalist, " in the beginning of August, in a box filled with garden ground, some common garden beans *(Vicia Faba)*, and buck-wheat *(Polygonum Fegopyrum.)* As soon as they began to rise, I cut off with a sharp pair of scissars the lobes from several of the beans, and the seminal-leaves at the same time from several plants of buck-wheat. Others I left untouched, in order to make the necessary comparison."

" After twelve days, having measured the first leaves of the beans deprived of their lobes, I found that these were scarcely two inches in length, having nearly the same breadth; whereas those furnished with lobes produced leaves of above three inches and a half in length, with about the same width. The same difference, or one analogous, subsisted also betwixt these plants during the whole time of their growth, so that they could easily be distinguished."

" The plants untouched produced a greater abundance of flowers, more pods, and larger, than the others."

Connubial fair! whom no fond transport warms
To lull your infant in maternal arms;
Who, bless'd in vain with tumid bosom, hear
His tender wailing with unfeeling ear;
The soothing kiss and milky rill deny
To the sweet pouting lip, and glistening eye!—
Ah! what avails the cradle's damask roof,
The eider bolster, and embroider'd woof!
Oft hears the gilded couch unpity'd plains,
And many a tear the tassel'd cuſhion stains!
No voice so sweet attunes his cares to rest!
So soft no pillow as his mother's breast! DARWIN.

The spell of faſhion, we hope, however, will soon be broken, and the conduct of her Grace the Duchess of Devonshire be generally imitated, who is thus complimented by Mr. ROSCOE.

Thus late with angel grace along the plain,
Illustrious DEVON led Britannia's train,
And whilst by frigid faſhion unreprest,
She to chaste transports open'd all her breast,
Joyed her lov'd babe its playful hand to twine
Round her fair neck, or midst her locks divine,
And from the fount with every grace imbued,
Drank heavenly nectar, not terrestrial food.
Be yours the task to break the wizard charm,
At once the spell of fashion to disarm;
So shall the glorious deed your sex inspire,
All earth applaud you, and all heaven admire.

" The removal of the seminal-leaves in the buck-wheat had a still greater effect than with the beans."

" Almost all the plants of the former, which underwent that operation, perished: and those which survived the loss, remained so stinted, that, in comparison with the others, they were as the smallest dwarfs to the biggest giants, or as plants growing upon the most barren land to those flourishing in the most fruitful."

" After three weeks their height was only an inch, the length of their longest leaves but four lines, with two and a half in breadth: whereas, those possessed of their seminal-leaves had grown six inches in height, and the length of their largest leaves was twenty-seven lines, with a breadth nearly equal."

" The former did not put forth flowers before the 12th of September; whereas the others were in full bloom on the 2d."

" This on the 24th of October had arrived at only five inches in height, had no lateral branches, produced the smallest flowers, and very few, which remained steril: whereas, the others were actually two feet five inches in height, were loaded with branches, and produced abundant flowers, bearing fruitful seeds *."

As the bean seemed to be less injured by the deprivation of the lobes, Bonnet made the following experiment.

" I put," says he, " some beans in sponge full of water."

" When they began to swell, and the lobes to separate, I cut them off from that part where they were united by two small bundles of fibres to the plantule."

" These germs (consisting of the plume which presented its leaves artfully folded one upon the other, and inclined towards its other part the ra-

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* This vegetable fact might teach us a lesson respecting the rearing of our own offspring. It is of great importance to be informed, that no food is so fit for the babe as that which Nature has kindly prepared for him. But the moment a child enters into the world, that instant he is crammed with gruel, pap, and other improper diet, and no wonder he should afterwards become dwarfish, distorted, pot-bellied, and unhealthy. It is in vain that this analogy be shewn to the inconsiderate.

For you no Dryads dress the roseate bower,
For you no Nymphs their sparkling vases pour;
Unmarked by you, light Graces swim the green.

It cannot, however, fail to strike those,

——whose mind the well-attemper'd ray
Of Taste and Virtue lights with purer day;
Whose finer sense, each soft vibration owns
With sweet responsive sympathy of tones. DARWIN.

dicle) I planted on the 10th of August in a pot filled with garden mould. They were buried in the earth as far as the origin of these folded leaves."

" I watered them frequently, and had the precaution of keeping them sheltered from the sun."

" The radicle, in every instance, nourished solely by the earth, pushed forth side roots, but it required twelve days before the tender leaves lifted up their heads, and expanded."

" As soon as these plants appeared sufficiently rooted, I exposed them to the sun and air, and still continued watering them: but they maintained so dwarfish an appearance, that the most experienced botanist would have been at a loss to have discovered what they were, or at any rate would have taken them for a new species of bean, remarkable for its diminutive size."

" These plants in miniature, only two inches high, with the largest leaves but five lines in length, and one in breadth, flowered on the 19th of October, but these were proportionably small, and few, and came to nothing: whereas the others of the same age, and in the same earth, were a foot and a half in height, and their longest leaflet *(foliolus)* was seven inches and a half, and five in length."

These seminal leaves, which may be called appendages to the lobes, or " effoliated lobes," serve then the same office, and prepare a similar fluid.*

* It is the sweetness of this fluid in the seminal leaves of the turnip that invites the *field slug* (Limax agrestis), which produces to the farmer oftentimes an evil incalculable. Whole ages had passed away in deploring this evil, without finding a remedy: the honour was reserved for Mr. Vagg, a farmer at Chilcompton, who first discovered a simple remedy for so great a calamity. He observed that these depredators left their dens in the still hour of night, and that in the morning were only found the horrid traces of their devastations. To destroy such a host one by one would be impossible. As plants have the wonderful property of rearing their heads afresh, when trodden down, he struck upon the useful idea of a roller, weighty enough to crush these robbers, but which at the same time might leave the young plants uninjured; and he rolled by night; and his success corresponded with his expectations, and obtained for him that reward, which this discovery entitled him to, which was three thousand pounds, collected by a general subscription among the farmers and gentlemen of the kingdom, to be paid when the secret was divulged.

The fly, called on this very account the *turnip-fly* (Chrysoméla olerácea, quæ habitat in Europæ plantarum cotyledonibus, præsertim tetradynamarum, quas misère destruit. LIN.), is another enemy to the Seminal-leaves, which not unfrequently sweeps off in a few days whole tracks, whose destruction has much exercised the ingenuity of man.

1. Some farmers, suspecting that it was engendered in dung, have sowed their seeds in unmucked soil; and as soon as the plants have put forth the rough leaf, which is uninviting to the fly (this they style being *up*, and *drest*), have then transplanted them into the well cultivated field.

2. Others again, entertaining the same suspicions, have laid on the manure in the autumn preceding sowing, by which means this noxious quality is said to have been prevented; and this method posseses another advantage, namely, that all the seeds contained in the dung are mostly killed by the severity of winter.

In concluding this chapter, it may be proper just to mention, that Botanists have made three great classes, or divisions, of the Vegetable world, from the observance of the Cotyledons *(Lobuli)*, and Seminal Leaves *(Folia seminalia)*; and have divided Plants into

I. MONOCOTYLEDONES,[†]	Plants having *one Cotyledon.*
II. DICOTYLEDONES,[‡]	.... *two Cotyledons.*
III. ACOTYLEDONES,[§]	.... *no apparent Cotyledon.*

We may remark in a few words concerning this method, that the distinction of classes from the number of lobes, or seminal leaves, as is done by Ray, is of all others the most unsatisfactory:

For if the unknown plant has passed, though never so little, its first stage of vegetation, so that the expansion of the lobes of the seed are no longer visible, in vain do we attempt even the first advance, and have to stop, until its ripened seeds have, in germinating, protruded its seminal leaves: and then we have again to wait until it grows up, and produces perfectly its leaves, flowers, and fruit.

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3. Others, about Midsummer, wait for the first opportunity of rain, or when the heavens threaten an immediate shower, when they sow their turnip-seed; for the natural heat of the ground, aided by moisture, especially at this season, gives an uncommon quick vegetation to the seed, which will be up in a few days, and out of all danger from the fly.

4. As the sweet smell of the turnip has been thought by some to attract the fly, attempts have been made to overpower that smell by others that were found from experience to be disagreeable. Hence some strew soot and tobacco over the field when the turnips appear; and others again trail over the young turnips the boughs of the elder tree, fixed in a gait or hurdle, most usually fumigated with the smoke of burnt tobacco mixed with a small quantity of aſſafœtida.

5. Others, again, attempt to suffocate these insects by the smoke of burning weeds.

6. Others spread lime over the young plants, but as only covering the outer surface of the leaves, the under parts remain unprotected, and the lightest rains washing off the lime, it can be esteemed only a partial remedy.

7. As the fly in immense swarms appear in a field, and in a few days after not unfrequently take their flight to some other field, some farmers taking advantage of this, have employed the following method. As new seeds vegetate sooner than old, they make an equal mixture of the two, and sow them, in hopes that if the early plants are destroyed, the fly may take its flight before the others are in a condition to entice them; and some, for the same purpose, steep the seed for two days, and sow this, with an equal quantity of dry seed.

8. But the device of Mr. Reynolds is the most curious, who sows double the quantity of radish as of turnip seed, for the radish he found was most agreeable to the flies, who fall upon these first; and whilst they are engaged with these, the turnips get so far advanced, as to be out of all danger.

[†] From μονος, and COTYLEDON, a cotyledon, here used for the lobe, or seminal leaf, being such plants as have one lobe, and consequently rise with only one seminal leaf.

[‡] From δις, two, and COTYLEDON, a cotyledon, plants whose seeds have two lobes, and generally rise with two seminal leaves. Most plants are of this kind.

[§] From α, not, and COTYLEDON, a cotyledon; plants whose seeds are not furnished with cotyledons, or lobes, and consequently put forth no seminal leaves. These parts, as in mushrooms, ferns, and mosses, have not as yet been ascertained, but they most probably exist in them, as well as the others.

SECT. VII.

II. THE NATURE OF OUR ATMOSPHERE.

> GNOMES! with nice eye the slow solution watch,
> With fostering hand the parting atoms catch.
>
> DARWIN.

> *Water* and *air*, says Sir Isaac Newton, composed of old worn particles and fragments of particles, would not be of the same texture and nature now as at the beginning, did not the *primitive particles* of *matter* continue *entire*, and *compose bodies* of *one* and the *same nature and texture in all ages*. The changes of corporeal things are to be placed only in the various separations and new associations of these *permanent particles*. OPTICS, page 376.

PREVIOUS to our entering into the consideration of the connexion betwixt air and vegetable life, it may be proper, for the sake of some of our readers, to contemplate first some chemical discoveries which have done honour to this age, and immortalized the names of Priestley, Cavendish, and Lavoisier.

The Hon. Mr. Boyle has considered *our atmosphere* as *one large chemical vessel*, in which an infinite number of various operations are constantly performing. In it all the bodies of the earth are continually sending up a part of their substance by evaporation, to mix in *this great alembic*, and to float a while in common. Here minerals from their lowest depths ascend in noxious vapours to make a part of the general mass; seas, rivers, and subterraneous springs, furnish their copious supplies; plants receive and return their share; and animals, that by living upon consume this general store, are found to give it back in vast quantities when they die.

The *air*, therefore, which every where presses on us, and upon which we subsist, bears very little resemblance to that *pure, simple, elementary body* generally imagined; and which is rather a substance that can be conceived, than experienced to exist.

Chemistry, however, has made of late great advances in *this curious research,* and it will soon appear that the composition of atmospherical air has been more *rigorously* determined.

Chemistry affords two general methods of ascertaining the constituent principles of bodies, the method of *analysis,*[*] and that of *synthesis.*[†]

When, for instance, by combining *water* with *alkohol,* we form the species of liquor called *brandy,* we certainly have a right to conclude (by this synthesis) that *brandy* is composed of *alkohol* and *water.* And when, by distillation of *brandy,* we obtain, separate, *water,* and *alkohol* (by this analysis), our evidence of the constituent principles of *brandy* is then rendered complete; and in general it ought to be considered as *a principle* in chemical science, never to rest satisfied without *both these species of proofs.*

THE MODERN ANALYSIS
OF
ATMOSPHERIC AIR;

Or its Separation into Two Elastic Fluids, { 1. VITAL AIR. 2. AZOTIC AIR.

LAVOISIER'S EXPERIMENT.

This illustrious chemist having placed 83 *grains* of fluid *mercury* in a *retort,* adapted to a *bell-glass,* which enclosed 100 *cubical inches* of *common air,* he kept up in his furnace a constant fire, of such force, as to keep the *quicksilver* almost always at its *boiling point.*

On the second day small *red particles* began to appear on the surface of the *mercury,* which gradually increased in size and number for four or five days.

Convinced that the *calcination* of the *mercury* after that time did not go on, he extinguished the fire; and when the vessel was cool, he found in his bell-glass, instead of 100 *cubical inches of air,* only 86, and therefore *a loss* of 14 *cubical inches* of *air.*

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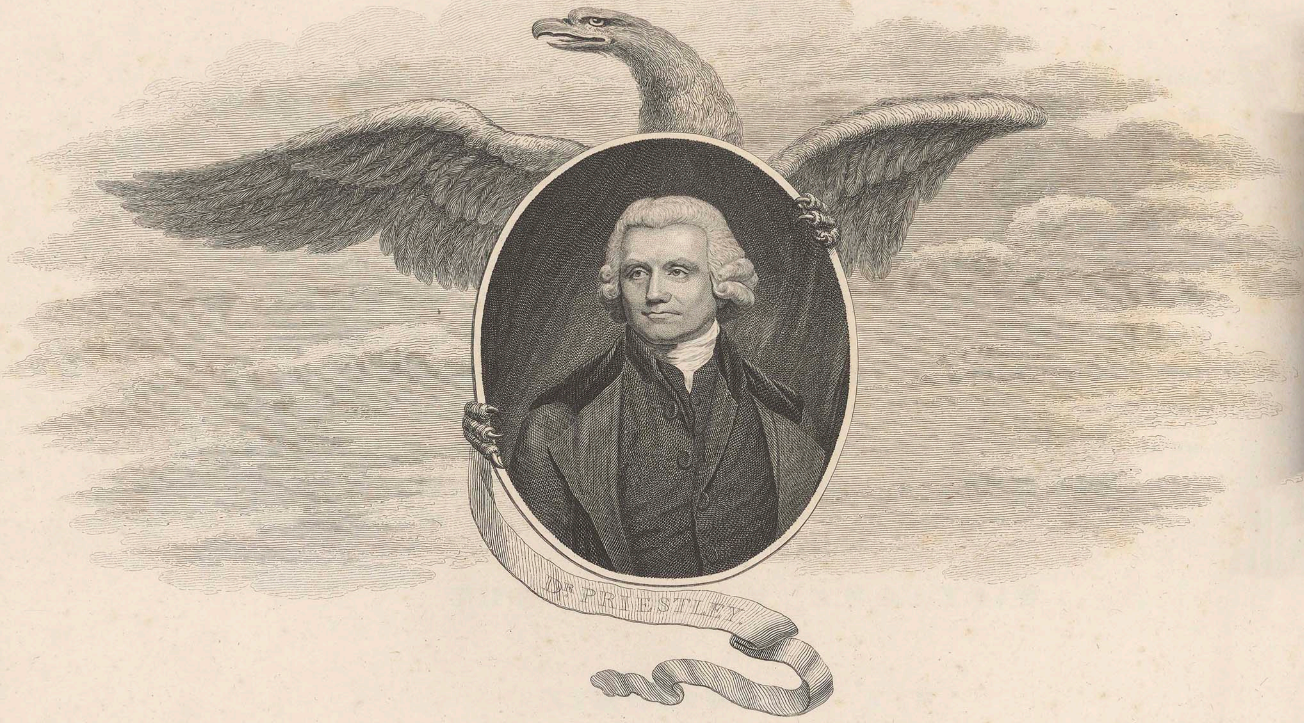
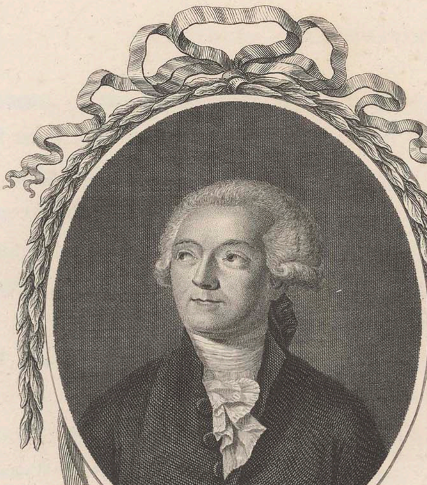
[*] From the Greek word αναλυσις. The *separation* of any *compound* into its *several parts.*

[†] From the Greek word συνθεσις. The *putting together* the *several parts* of a *compound body.*

Chemical Philosophers of the present Day.


Dr PRIESTLEY.



Opie and David pinxt

London Published May 1, 1801, by Dr Thornton.

Now, 14 *cubical inches* of *air* weighs 7 *grains*, and the *red particles* or *calx of mercury*, being carefully collected, weighed 90 *grains*. The *mercury*, therefore, by being calcined, had acquired an *increase of weight* of 7 *grains*, the *exact weight* of *air* which seemed *lost*.*

The 86 *cubical inches* of *air* remaining in the glass after this calcination was ended being examined, it was found to possess *these distinguishing properties*.

An animal being put into it was *suffocated* in a few minutes,...and when *a taper* was plunged into it, it was *extinguished*, as if it had been immersed in water.

This gas, or *air*, has been called *phlogisticated air*, *non-respirable air*, *noxious or mephitic air*, *impure air*; but the French chemists have preferred the term *azotic gas (lethal air)* from the Greek words α, *privative*; and ζωη, *life*, as *this air* so quickly destroys life.

LAVOISIER'S SECOND EXPERIMENT.

Having taken 90 *grains* of the *calx of mercury*, the product of the *last process*,† Lavoisier put it into a glass retort fitted to a proper apparatus for receiving aerial products.

Having applied a *much stronger heat* than in the former experiment, he observed that at first, in proportion as the *calx* of *mercury* became heated, the intensity of its colour augmented; but soon after the *calx* began gradually to decrease in bulk, and in a few minutes *its red colour altogether disappeared*, and the 90 *grains of calx of mercury* was converted into the 83 *grains* of *running mercury*, and 14 *cubical inches* of an *aerial fluid* passed over into the recipient.

Now these 14 *cubical inches* of air weighed 7 *grains*, the *exact weight* of the air *consumed* by the *calcination* of the *mercury* in the first experiment;‡ and the 83 *grains* of the *calx* of *mercury reduced* § to a *metallic*

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* The conclusion is obvious; and in the next experiment we shall find, that the 14 *cubical inches of air*, which was *absorbed* by the *mercury*, and converted it to a *calx*, was the *vital* or *respirable part* of our air.

† Not from any peculiar property of its own, but because the *vital* or *respirable part* was abstracted from it, as will be seen from the next experiment.

‡ Had the 100 *cubical inches* of atmospheric air contained a larger share of *oxygen* or *vital air*, *more mercury* would have been *calcined*. For *calcination*, as this experiment shews, is nothing more than the *combination* of *vital air* with *any metallic* body.

§ From the Latin word *reduco, to bring back*. *Reduction* is the bringing back a *metal converted into a calx* to its *pristine state*.

state being examined, had *lost in weight 7 grains*, the *exact weight* of the air now obtained. *This air* possessed these *peculiar properties*.

An animal being placed in *it*, became *remarkably lively*; a *taper* burnt in it with a *dazzling splendour*; and *charcoal*, instead of consuming quietly away, as it does in common air, burnt *with a flame*, attended with a decrepitating noise, and threw out such a *brilliant light* that the eyes could hardly endure it.

This species of air was *discovered* almost at the same time by Dr. Priestley, and Mr. Scheele. Dr. Priestley gave it the name of *Dephlogisticated* or *Pure Air*; Mr. Scheele called it *Empyreal Air*; and Lavoisier first named it *Highly Respirable Air*, or *Vital Air*; and afterwards, as it forms acids, by combining with certain bodies, he adopted the term *Oxygen Gas (Acid-making Air)*, from the Greek words υξυς, *sour*; and γεινομαι, *to beget**.

THE SYNTHESIS,

Or Reunion of { 1. VITAL AIR,
AND
2. AZOTIC AIR.

Lavoisier then repeated the same experiments as before related, and re-combined the two elastic fluids, which he had separately obtained in the two experiments of *calcination* and *reduction*, viz. the 84 cubical inches of the AZOTIC AIR, and the 14 cubical inches of the OXYGEN AIR, and he produced from this combination an elastic fluid precisely similar in all its properties to atmospheric air, contributing in the same way to a repetition of the same experiments, and possessing exactly the same power of supporting animal life, and combustion.

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* If sulphur or charcoal be burnt in oxygen or vital air, in a close vessel, and the fumes be condensed in water, this water will acquire an acid taste, and be increased in weight exactly corresponding to the weights of sulphur or charcoal consumed, and that of the oxygen air destroyed. Sulphur united thus with oxygen, the fumes being collected in water, will form vitriolic acid; and charcoal combined with oxygen, and diffused in water, will form the carbonic, or aerial acid water.

The calces of metals the French chemists call oxyds, which signifies a body impregnated with a certain quantity of oxygen, but not sufficient to render it perceptibly acid. It is from these chiefly that we obtain the pure vital air. The oxyd of manganese parts with its oxygen so readily, that if pounded and put into an iron retort with but a moderate heat from the furnace, the air will be forced from it, and passing along an iron tube, whose termination is in water, will enter into any vessel filled and inverted over the pneumatic tub, and afford the pure separate oxygen air, the just pride of modern philosophy. This air is most fit for medicinal purposes. If vitriolic acid (sulphur and oxygen) be added to the manganese in a glass vessel, the mere heat of an Argand lamp will be sufficient to produce speedily enough of pure oxygen air for the performance of chemical experiments.

CONCLUSION.

The philosopher can have no remaining doubt as to the composition of atmospheric air; but the circumstances of these experiments might appear to him more correct, though probably at the time less clear to others, were it said, that *mercury*, at a certain temperature, overcoming the *affinities*[*] of

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It was a metallic calx that gave origin to Dr. Priestley's famous discovery of *vital air*. "On the 1st of August, 1773, I endeavoured," says this illustrious philosopher, "to extract air from *mercurius calcinatus per se*; and I presently found that, by means of a very large burning-glass, an *aerial fluid* was expelled very readily. Having got three or four times as much as the bulk of the materials, I admitted water to it, and found it was not fixed air, because water did not absorb it. But what surprised me exceedingly was, *that when a candle was put into this newly acquired air, the flame, besides being larger, burnt with considerable more splendour, and heat, than in common air; and a piece of burnt wood that had any redness in it, was rekindled and burnt away very fast, resembling by its crackling noise paper that had been dipped in a solution of nitre.*"

"I extracted," he adds, "in the same way, a quantity of *air*, with the very *same property*, from the common *red precipitate*, which had been produced by a solution of mercury in spirit of nitre, and hence I concluded that this peculiar property was derived in both instances from *nitrous particles*. I even thought that what was usually sold as the *mercurius calcinatus per se* was contaminated with *nitrous acid*. However, upon mentioning this suspicion to Mr. Waltire, he furnished me with some, which he assured me was genuine. This being treated in the same manner as the former, only by a longer continuance of heat, I extracted much more air from it than from the other. This experiment might have satisfied any other; but being at Paris in the October following, and knowing that there were several very eminent chemists in that place, I did not omit the opportunity to get an ounce of *mercurius calcinatus* prepared by Mons. Cadet; of the genuineness of which there could not poſſibly be any suspicion; and at the same time I frequently mentioned my surprise at *the kind* of *air* I had got from this preparation to Mons. Lavoisier, and several other philosophers who honoured me with their notice in that city.

"At the same time that I had obtained the air above described from the *mercurius calcinatus* and the *red precipitate*, I also procured some of the same kind from *minium*, or *red lead*. As I never made the least secret of any thing that I observed, I mentioned this experiment *also* to all my philosophic acquaintance at Paris, and elsewhere; having no idea at that time to what these remarkable facts would lead."

Lavoisier, however, was the first who turned this important discovery to account. In a late work by Dr. Priestley he says, respecting the nature of the composition of the air, "For my own part, I will frankly acknowledge, that at the commencement of the experiments recited, I was so far from having formed any hypothesis that led me to the discoveries these produced, that they appeared to me improbable when I heard of them; and when the decisive facts did at length obtrude themselves upon my notice, it was very slowly, and with great hesitation, that I yielded to the evidence of my senses. And yet, when I reconsider the matter, and compare my last experiments relating to the constitution of the atmosphere with my first discovery, I see the closest and easiest connexion between them, so as to wonder that I should not have been led immediately from the one to the other. That this was not the case, I attribute to the force of prejudice, which, unknown to ourselves, biasses not only our judgments properly so called, but even the perceptions of our senses; for we may take a maxim so strongly for granted, that the plainest evidence of sense will not entirely change, and often hardly modify, our persuasions; and the more ingenious a man is, the more effectually he is entangled in his errors; his ingenuity only helping him to deceive himself by evading the force of truth."

[*] If you take a bullet and divide it with a knife into two parts, provided these be smooth and rubbed together, they will ſtrongly unite and form one whole. This is from a law impressed on matter called the *attraction of cohesion*. But should a particle of sand, or any roughness exist, the particles being divorced from each other, beyond the sphere of mutual attraction, they are no longer actuated by this law.—The attraction of cohesion in mercury, at the common temperature, hinders the admission of oxygen, for which it has an elective attraction or affinity. But when exposed to a

caloric[*] and *azotic air* for *oxygen,* attracts and fixes within itself *oxygen*[†], (the *base* of oxygen air, for oxygen air is oxygen combined with a certain quantity of caloric:)...hence its *increase of weight,* and its *conversion into an oxyd or calx,* and hence the *azotic,* or *lethal, air left us* in the bell-glass....

That the temperature being increased[‡], the affinity of the *caloric* for *oxygen* becoming now superior to the attraction of the *mercury,* the *oxygen* is withdrawn from the *oxyd of mercury* by the superior attraction of the *caloric*;... hence its *decrease in weight,* and its *restoration to fluidity and splendour,* and hence the produce of *oxygen,* or *vital, air,*...clearly displaying to us this important Truth;

That atmospheric air is actually a compound of two heavy substances, AZOT[§] *and* OXYGEN;[||] *which bodies, when combined with* CALORIC, *or the matter of heat, are aeriform, and may be procured in separate states,* viz. *in the condition of* AZOTIC *and* VITAL AIRS, *which being mixed in a certain proportion,* viz. 3 *of the former to* 1 *of the latter, constitutes our* ATMOSPHERE.

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a ſtrong heat, the caloric expands this fluid; that is, insinuates itself through the body, and separates its particles (thermometers depend on this expansive power of fire), and, like the pieces of the bullet where sand interposed, the divided particles are no longer subject to the law of cohesion; then it is they obey the law of attraction, and each atom of mercury attracts to itself a particle of oxygen, just as a loadstone would draw to itself a particle of iron—The loadstone only attracts iron. This represents the term *affinity* in chemistry. The mercury did not attract the azot, because chemists would say it had no affinity for it.

[*] Fire, or the matter of heat.

[†] An experimentalist would illustrate this by placing a needle between two magnets of different powers. This would represent oxygen between the two attractions of the caloric and azotic air. As we may suppose a loadstone to have an attraction for the needle superior to the two magnets, so would it draw the needle to itself from these, just as the mercury draws away from the *azotic air* and *caloric* the *oxygen.*

[‡] This is a curious fact; the temperature being increased, the *caloric alone* overcomes the elective attraction of *mercury* for *oxygen,* and depriving it of *that principle,* the *attraction of cohesion* takes place with the particles of *mercury,* and we obtain then *running mercury* and *oxygen gas.* To have recourse to the note * page 39, the *oxygen* and *mercury* being separated beyond their *sphere of attraction,* the *caloric* attracts to itself *oxygen,* just as either of the *magnets* (in the preceding note) would again attract to itself the *needle,* were it placed within its *sphere of attraction,* but *beyond that* of the *loadstone.*

[§] That *azot* is a *solid substance* as well as *oxygen,* will be proved when we come to treat on manures. That the application of heat should render *oxygen* and *azot gaseous,* is not wonderful, ſince we often observe *ice* by the admixture of *caloric* rendered a *fluid,* and heated to 212, converted into an aeriform and transparent gas. The hardest substance in the world, the *diamond,* may be volatalized in the same way. Mon. D'Arcet took a sphere of porcelain china, and after cutting it into halves, confined a *diamond* in the middle; he then joined the two sections ſtrongly together. Putting these balls into a furnace, he afterwards unscrewed them, and found the diamonds evaporated, and the place which they occupied empty, though he could perceive no chink or fracture any where over the surface of the ball!

[||] The distinction betwixt air and vapour is this, both are formed of *particles* held in suspension by caloric, or heat, but by cold, or condensation, vapours return in time to their original form, whereas *airs* continue *permanently elastic.*

SECT. VIII.

III. THE COMPOSITION OF OXYGEN AIR.

When the hard Steel combines with Vital Air,
And veils in *pearly clouds* the yielding fair,
Indignant Fire the treacherous courtship flies,
Waves his light wings, and mingles with the skies.*

Darwin.

THE ANALYSIS
OF
OXYGEN AIR;

Or its separation into its 3 Constituent Parts,
- 1. OXYGEN,
- 2. CALORIC, and
- 3. LIGHT.

In the slow calcination of metals, as in the former experiment with mercury, the disengagement of *light* and *heat* was too gradual to excite attention, and the fire of the furnace was confounded with it; hence we are indebted to Dr. Ingenhousz for a very beautiful experiment, clearly proving, that

OXYGEN AIR

Is composed of
- 1. OXYGEN,
- 2. CALORIC, and
- 3. LIGHT.

He took an *iron wire* (a watch-spring twisted in a spiral form exhibits this experiment best), and having fastened to one extremity a piece of *paper*, this he lights, and then thrusts the iron into a jar containing *vital air,* when the hot extremity immediately takes fire, and burns away rapidly, exhibiting a *dazzling light,* resembling the most brilliant fire-works,[*] a *white filmy ſmoke* is produced, and the iron, as it consumes, becoming saturated with oxygen, falls to the bottom of the glass in red-hot globules, which prove upon examination to be an æthiops, or oxyd of iron.

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* In order to accommodate the verses of the poet to our subject, some alterations have been found necessary; but the reader will easily call to mind the original words, and, I trust, pass the eye of candour over this most difficult part of our labour.

At the beginning of the combustion there is a slight augmentation in the volume of the air in the bell-glass, from the dilatation caused by the caloric or heat; but presently after a *rapid diminution* takes place, and *the mercury riſeſ in the glaſſ,* insomuch that when the *quantity of iron iſ ſufficient,* and the *oxygen air operated on iſ very pure,* almost the *whole air employed* is *abſorbed;*[†] or should the *quantity of iron be inſufficient,* the *remaining air unabſorbed* will be found *perfectly pure vital air.*

The *theory* of this experiment is the same as the last.

At a certain temperature *iron* has a *ſtronger affinity* for the *oxygen* than *caloric* and *light* have.

It *therefore* attracts to itself the *oxygen,* and *caloric* and *light* becoming disengaged, are rendered *active* and *evident* to the senses.

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[*] The rationale of fire-works are now no longer any difficulty. As *nitre* contains *vital air* in great abundance, from the combustion of different bodies, especially iron-filings, in *this air* arises so astonishing and pleasing a spectacle.

[†] That is, if 100 *grains* of *iron* be consumed in 70 *cubic inches of oxygen air,* the whole volume of air will disappear; and as 70 *cubic inches of oxygen air* weigh 35 grains, the 100 *grains of iron* will weigh, in its state of *æthiops, oxyd,* or *calx,* 135 *grains.*

SECT. IX.

IV. THE COMPOSITION OF WATER.

NYMPHS! let your squadrons watch with chemic eyes
The fine elastic vapours, as they rise;
With playful force arrest them as they pass,
And to *pure air*[*] betroth the *flaming gas.*[†]

DARWIN.

PREVIOUS to our entering upon the subject of the effects of air on the vegetable œconomy, it will be necessary to shew, also, that *water,* though it be the solvent of a vast variety of bodies, is neither that *compound* or *simple element* formerly supposed, but made up of two *very distinct* and *different principles.*

The new and beautiful doctrine of the French chemist, respecting the composition of *air,* was daily gaining ground, and obtaining the applause of every one, when an experiment performed by Dr. Priestley made it for a while totter on its basis.

In the middle of a long glass tube this great experimentalist put some *calcined lead,* and affixed to the extremities *bladders* which were filled with *inflammable air.*[‡] Having applied a strong heat to the middle of this tube, he next squeezed the bladders, and forced the *inflammable air* along the tube.

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[*] *Oxgen air.*

[†] *Inflammable air,* very improperly denominated so; for, the burning of all bodies is nothing more, as we saw in the last section, than the *decomposition* of *oxygen air.* It is the oxygen air, therefore, and not the combustible body, that gives out *light* and *heat.* When we are sailing on the water in a still day, *distinct objects appear to meet us,* but our reason corrects the delusion. When we behold the sun, moving from east to west, philosophy again assumes its empire, and we are convinced it is *stationary.* If we take a *prism,* it displays to us a variety of colours; our reason tells us here also, that *theſe colours* arise from the *rays of light,* and are not *in the prism,*—so of the combustion of bodies, the *caloric* and *light* are not from *the wax* of our candles, but from the *oxygen air,* which, as we see in many experiments, becomes, under certain circumstances, *decomposed.* Vide note (*), page (41).

[‡] *This air* Dr. Prieſtley obtained from *diluted* vitriolic acid poured on iron. *Iron* was therefore said to contain a great quantity of *this air.* But the fact will soon appear that the air arose from the *decomposition of water* mixed with the vitriolic acid.

The *inflammable air* soon disappeared; no *oxygen gas* was evolved: but the *red lead* quickly *reassumed* its original metallic splendour.

A question then arose, whence *this property* in *inflammable air* which the *antiphlogistians* would ascribe to the evolution of *oxygen gas*.*

The favourers of the new system were not able to deny the fact; and as the inflammable air, which was now called *phlogiston*, had in this experiment disappeared, they found some difficulty to persuade the supporters of the old doctrine that the revival of the metal could not be from the absorption of the inflammable air, as the red lead had lost a good deal of its weight, and the effect of an addition of matter (if inflammable air be matter) could be no other than to give it an increase of weight.

THE SYNTHESIS
OF
WATER;

Or its formation from its { 1. HYDROGEN, and
Two constituent parts, { 2. OXYGEN.

Fortunately for chemistry the Hon. Mr. Cavendish, by passing an electric spark through *oxygen air*, mixed with *inflammable air*, produced water.†

The reduction of the *red lead* in Dr. Priestley's experiment was then no longer a matter of surprise. At a *certain temperature* the *inflammable air* overcoming the attraction of the *lead* for *oxygen* divorced it of *that principle*, and uniting with it formed *water*.

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* *Inflammable*, or *hydrogen air*, being 15 times lighter than common air, is employed for balloons. *Oxygen air* is even something heavier than common air. *Inflammable air* quickly destroys life, whereas *oxygen air* appears to be the very principle of life. *It* is considerably lighter than either *oxygen* or *common air*. *It* explodes when it comes into contact with *common air*, but more especially with *oxygen air*, provided any body in actual inflammation be present. The difference therefore between these two airs is very great.

† 85 grains, by weight, of *oxygen air*, and 15 grains of *inflammable* or *hydrogen air*, produced here precisely 100 grains of *water*. In this experiment *caloric* is disengaged, and the 85 parts of *oxygen* and 15 of *hydrogen* unite, which, being naturally *solid substances of themselves*, become, if nearly all the *caloric* be extracted from them, *ice*; if less, *water*.

THE ANALYSIS,

OR

Its separation into { 1. HYDROGEN AIR, and
2. OXYGEN AIR.

But that no doubt may be entertained on this head, I must beg leave to relate an experiment which was performed by Meusnier before a large assembly of the Academy of Sciences at Paris.

He took a *gun-barrel,* into which he put some thick pieces of *iron-wire* flattened by the hammer. He *weighed* the whole with a scrupulous exactness. He then *luted* the gun-barrel to secure it from the immediate contact of the fire. It was then placed in *a furnace,* but so *inclined* that water would easily glide down it.

He then adapted to the upper extremity a *funnel* containing water, from which it could not escape into the gun-barrel but drop by drop. This funnel was *closed at the top* to avoid any the least evaporation of the water.

At the lower extremity *vessels* were adapted to receive any aerial product. To use every precaution *these* were exhausted of their air.

The *gun-barrel* was now made red-hot, and the *water* from the funnel passed into it drop by drop. An astonishing quantity of *inflammable* or *hydrogen air*[*] was quickly obtained.

Having removed the luting, the *gun-barrel* with its *contents* weighed considerably *heavier* than *before*; and *the acquired weight* of the gun-barrel being *added* to the *weight* of the *inflammable air* thus produced, was *precisely* the *weight* of the *water expended* in the process: and the *iron-wire* found in the barrel (the process being over) resembled in every respect *iron* that has been consumed in *oxygen air,* that is, it was become *martial æthiops,* which accounts for the *oxygen,* the other constituent principle of water.

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[*] This *inflammable air* was generated from the *hydrogen* of the water, which united with the *caloric* of the furnace in its pasage through the barrel. *Inflammable air* the French chemists call *hydrogen gas,* from the Greek words ὑδωρ *water,* and γεινομαι *to beget.*

SECT. X.

V. THE COMPOSITION OF FIXED AIR.

Thus, by a length of years, and change of fate,
All things are light or heavy, small or great;
Hence Jordan's WAVES shall future *clouds* appear,
And Lebanon's tall CEDARS turn to *air*.
PRIOR.

SYNTHESIS

OF

CARBONIC ACID AIR, OR FIXED AIR;

Or the Union of its 2 CONSTITUENT PARTS, } 1. CHARCOAL, and 2. OXYGEN AIR.

As the composition of fixed air is easiest understood by Synthesis, we shall only mention, that if wood, or *Charcoal*, be burnt in *oxygen air*, it will be converted into an *acid gas*,[*] whose *weight* will equal the sum of the *weights* of the *charcoal* which has been consumed, and the *oxygen air* employed.[†]

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[*] The properties of *fixed air* are these; a candle or light is instantly extinguished in it, it soon destroys animal life, is heavier than either oxygen or common air, is quickly imbibed by water, giving to it the sparkling appearance, and taste, of Seltzer or Pyrmont water.

[†] From our experiment we find, that *fixed air* is composed of 28 *parts* of *charcoal* to 72 of *oxygen air*; or, in other words, 144 *cubic inches* of *that air* will saturate, or take up, 28 *grains* of *charcoal*.

SECT. XI.

VI. THE CONNEXION OF AIR WITH VEGETATION.

Go, gentle GNOMES! resume your vernal toil,
Seek my chill tribes, which sleep beneath the soil;
Oh, watch, where bosom'd in the teeming earth,
Green swells the germ, impatient for its birth;
Guard from rapacious worms its tender shoots,
And drive the mining beetle from its roots;
With ceaseless efforts rend the obdurat clay,
And bring my vegetable babes to day!—
  See, from bright regions, borne on odorous gales,
The swallow, herald of the summer, sails;
THOU, whose soft voice calls forth the tender blooms,
Whose pencil paints them, and whose breath perfumes;
O chase the Fiend of Frost, with leaden mace,
Who seals in death-like sleep my hapless race;
Melt his hard heart, release his iron hand,
And give my seeds the power to expand.
Pervade the city dank, and heaving earths,
Where teeming Nature broods her myriad births;
Fill the fine lungs of all that *breathe* or *bud*,
Warm the new heart, and dye the gushing blood,
With life's FIRST SPARK inspire the organic frame,
And, as it wastes, renew the subtle flame.
DARWIN.

It is the GODDESS who presides over Botany who is here supposed to address her attendant *Gnomes*, *Sylphs*, and *Zephyrs*. Her several addresses form the first part of the *Botanic Garden*, a poem which was intended to enlist the imagination under the banners of science, and to lead her votaries from the looser analogies, which dress out the imagery of poetry, to the stricter ones which form the reasonings of philosophy. The GODDESS is thus invoked by the sublime Poet.

Winds of the North! restrain your icy gales,
Nor chill the bosom of these happy vales!
Hither, emerging from yon orient skies,
BOTANIC GODDESS! bend thy radiant eyes;
O'er these soft scenes assume thy gentle reign,
Pomona, Ceres, Flora, in thy train;
O'er the still dawn thy placid smile effuse,
And with thy silver sandals print the dews;
In noon's bright blaze thy vermil vest unfold,
And wave thy emerald banner star'd with gold.

She comes!—the Goddess!—through the whispering air,
Bright as the morn, descends the blushing car;
Each circling wheel a wreath of flowers entwines,
And gem'd with flowers the silver harness shines;
The golden bits with flowery studs are deck'd,
And knots of flowers the crimson reins connect.
And now on earth the silver axle rings,
And the shell sinks upon its slender springs;
Light from her airy seat the Goddess bounds,
And steps celestial press the pansied grounds.—
And soon the Goddess, with attention sweet,
Turns to the *Gnomes,* who circle round her feet.

After the discovery of the air-pump by Boyle, it was natural to expect that experiments would be made with it upon plants, as well as animals. Accordingly we find in the first volumes of the Philosophical Transactions, published in 1665,*

"PROPOSALS"

" To try the Effects of the Pneumatic Engine exhausted, in Plants, Seeds, Eggs of Silkworms, &c."

" The noble Mr. Boyle suggests, as proper for the approaching spring, that it may be tried,"

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* The idea of a literary society seems first to have originated with the great Lord Bacon, the father of modern philosophy, who recommended to the reigning prince to institute societies of learned men, who should give to the world from time to time a regular account of their researches and discoveries. It was the idea of this great philosopher, that the learned should be united, as it were, into one immense republic; which, though consisting of many detached states, should hold a strict union and preserve a mutual intelligence with each other, in every thing that regards the common interest. The want of this union and intelligence he laments as one of the chief obstacles to the advancement of science; and, justly considering the institution of public societies, in the different countries of Europe, under the auspices of the sovereign, to be the best remedy for that defect, he has given, in his fanciful work, the New Atalantis, the delineation of a philosophical society on the most extended plan, for the improvement of all arts and sciences; a work which, though written in the language, and tinctured with the colouring of romance, is full of the noblest philosophic views. The plan of Lord Bacon, which met with little attention from the age in which he lived, was destined to produce its effect in a period not very distant. The scheme of a philosophical college by Cowley is acknowledged to have had a powerful influence in procuring the establishment of the Royal Society of London by charter from Charles II.; and Cowley's plan is manifestly copied in almost all its parts from that in the New Atalantis.

At this period Mr. Boyle, Mr. Wren, Lord Brounker, Dr. Wallis, and other learned men, held meetings at Oxford, in which were received accounts of whatever was doing in the study of Nature; and many experiments were exhibited. The researches of Galileo, Toricelli, and Paschal, concerning

1. " Whether seeds, especially such as are of hasty growth, videlicet. orpin, lettice, garden-cress seeds, &c. will germinate and thrive in the exhausted receiver of an Air-Pump?"

the pressure of the air, greatly engaged their attention, and many additions were made to their discoveries. Mr. Boyle, the most ardent and successful studier of Nature, had the principal share in these improvements, his inquisitive mind being aided by an opulent fortune. In a letter to his nephew, Lord Dungarvon, he says, that he made many attempts to see the appearances exhibited by bodies freed from the pressure of the air. He had made Toricellian tubes, having a small vessel at top, into which he put some bodies before filling the tubes with mercury; so that when the tube was set upright, and the mercury run out, the bodies were *in vacuo*. He had also abstracted the water from a vessel, with a small pump, by means of a weight, having previously put bodies into the vessel along with the water. But all these ways were very troublesome and imperfect. He was delighted when he heard from Schottus's first publication, that Counsellor Guericke had effected this by the expansive power of the air; and immediately set about constructing a machine from his own ideas, no description of Guericke's being then published.

It consisted of a receiver, furnished with a stopcock and syringe, placed in a vertical position below the receiver. Its valve was in its bottom, close adjoining to the entry of the pipe of communication; and the hole by which the air issued was farther secured by a plug which could be removed. The piston was moved by a wheel and rackwork. The receiver of Guericke's pump was but ill adapted for any considerable variety of experiments; and accordingly very few were made in it. Mr. Boyle's receiver had a large opening, with a strong glass margin. To this was fitted a strong brass cap, pierced with a hole in its middle, to which was fitted a plug ground into it, and shaped like the key of a cock. The extremity of this key was furnished with a screw, to which could be affixed a hook, or a variety of pieces for supporting what was to be examined in the receiver, or for producing various motions within it, without admitting the air. This was farther guarded against by means of oil poured round the key, where it was retained by the hollow cup-like form of the cover. With all these precautions, however, Mr. Boyle ingenuously confesses, that it was but seldom, and with great difficulty, that he could produce an extreme degree of rarefaction; and it appears by Guericke's letter to Schottus, that in this respect the Magdeburgh machine had the advantage. But most of Boyle's very interesting experiments did not require this extreme rarefraction; and the variety of them, and their philosophic importance, compensated for this defect, and soon eclipsed the fame of the inventor to such a degree, that the state of air in the receiver was generally denominated the *vacuum Boyleanum*, and the air-pump was called *machina Boyleana*.

He was soon assisted by Dr. Hooke, the most ingenious and inventive mechanic that the world has ever seen. This person made a great improvement on the air-pump, by applying two springes, whose piston-rods were worked by the same wheel, and putting valves in the pistons, in the same manner as in the piston of a common pump. This evidently doubled the expedition of the pump's operation: and it also greatly diminished the labour of pumping; for it must be observed, that the piston must be drawn up against the pressure of the external air, and when the rarefaction is nearly perfect, this requires a force of nearly fifteen pounds for every inch of the area of the piston. Now when one piston is at the bottom of the barrel, the other is at the top of the barrel, and the air below is equally rare with that in the receiver. Therefore the pressure of the external air on each of the pistons is nearly equal. Both, therefore, are acting in opposite directions on the wheel which gave them motion; and the force necessary for raising the piston is only the difference between the elasticity of the air in the two barrels. This is very small in the beginning of the stroke, but gradually increases as the piston descends, and becomes equal to the whole excess of the air's pressure above the elasticity of the remaining air of the receiver when the air of the natural density begins to open the piston valves. An accurate attention to circumstances will shew us that the force requisite for working the pump is greatest at first, and gradually diminishes as the rarefraction advances; and when this is nearly complete, hardly any more force is required, than what is necessary for overcoming the friction of the pistons, except during the discharge of the air at the end of each stroke. This is then the form of the air-pump which is most generally used all over Europe. *Encycloped.*

2. “ Whether the exclusion of air from the sensitive plant would be harmful to it?”

3. “ Whether silkworms’ eggs will be hatched in such an exhausted receiver, in the proper season.”

“ To which may be added,

4. “ The trials of putting in a vial full of water, some of those herbs that will shoot and grow in water alone, including them in such a receiver, and pumping out what air you can, to see whether they will then shoot, or not?”

“ And though some of these proposals have been formerly begun to be experimented, yet ought they to be diligently prosecuted, to see how far the air is necessary to vegetation; and whether plants do indeed live as much upon the air, as the earth; and the branches of them are rooted, as it were, in and quickened by the air, as their roots are planted and nourished in and by the earth.”

“ The experiment heretofore made of this kind was, that some lettice-seed being sown upon the earth in the open air; and some of the same seed at the same time upon another earth in a glass receiver of the abovementioned engine, afterwards exhausted of air; the seed exposed to the air was grown up an inch and a half higher, within eight days; but that in the exhausted receiver, not at all: and, air being again admitted into the said emptied receiver, to see whether any of the seeds would then come up, that in the space of one week they were grown up to the height of two or three inches.”

The great Boerhaave, speaking on this subject, says, “ That the eggs of every kind of insect, accurately inclosed in a small glass vessel, however exposed to the influence of the sun, do not come forth; and that plants committed to the ground, and the proper heat administered, if prevented from having access to the air, do not vegetate.”

The celebrated Spalanzani, repeating the experiments of Boerhaave, found indeed that the eggs and seeds did not germinate, when confined in a very small quantity of air; and he endeavours to account for the *cause* of this *sterility*. “ Mons. de Reaumur,” says he, “ took the crysalids of the cabbage caterpillar, and put them into glass tubes four or five inches long, which were hermetically sealed: but they remained in their original state, although confined for several months, whereas other crysalids of the same kind were changed into butterflies."

"Under these circumstances there issues a noxious vapour from the crysalis, when in a confined place, and this reverting back on the subject, renders it *diseased*, and thus destroys it, as with animals confined in stagnant air."*

"The same thing," continues this naturalist, "happens to *seeds*. We know that they germinate only at a certain degree of heat, which occasions, an evaporation; and being confined in a small vessel, they in consequence reabsorb the exhalations which they had before transpired, and then become corrupt. Upon taking out seeds which had been so exposed, I have often found the surface covered by a humid pellicle."

If this great naturalist had carried his trials but a step further, he would have found that his seeds would have vegetated, and that the exclusion of the air alone had hindered the expansion of the living principle.

Hence it is, upon digging deep in the ground, plants have often been known to appear, not before observed in that district for time immemorial.

Morrison observes, "That after the late prodigious conflagration of the city (namely, the fire of London in 1665), the ruins being dug up, there grew spontaneously the Sisymbrium Irio *(Broad-leaved Hedge Mustard)*, a rare plant in those parts, but now so abundant, as to exceed the produce of all Europe besides."

Two years ago a crop of wild mustard was reaped from the banks raised at Hull to form a dock for the reception of shipping; and it has been often noticed, that a spontaneous crop of this vegetable makes its appearance, for two successive years, upon the banks of all drains made in Holderness.

"Similar appearances," says Dr. Hunter, "have been observed in the isle of Oxholme, and other low countries."

"The Lobelia *(Cardinal Flower)*," says Linnæus, "six years ago, suddenly reappeared in the Physical Gardens at Amsterdam, which had been lost there upwards of twenty years."

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* The error of this supposition has been successfully refuted by modern philosophers; for since the discovery of the composition of the atmosphere, and its separation into oxygen, and azotic, airs, it has been found after animals have died in a vessel with a given quantity of air, without removing the supposed noxioùs effluvia, oxygen air being added to the vessel, animals have then lived as freely, or even better, than in common air.

" And the Hypecoum Procumbens *(Procumbent Hypecoum)*, which had been lost in the garden of Upsal since the time of Rudbeck the father, also appeared as they were breaking up the earth in a particular part, the seeds having laid dormant there upwards of forty years."

Hence we may conclude that, independent of heat and moisture, another requisite is necessary towards the first growth of seeds, namely, *air*.

But what will clear up this subject best are direct experiments made with the view to ascertain this curious point.

EXPERIMENT I.

December 2d, 1796, a quantity of barley, after having been soaked in water twenty-four hours, was put into a wine glass, and introduced under a jar containing *common air*, which was afterwards inverted over water to prevent the escape of air,

It may be necessary to remark, that the temperature in this, as well as the other experiments about to be related, was from sixty to seventy degrees, as nearly as possible.

At the expiration of five days they began to vegetate, and at the end of twenty-eight days the plume had shot out half an inch in length.

On February 7th, vegetation was still going on, and the air in the jar was *diminished*, and the barley being withdrawn was found to be very sweet, and converted nearly into the state of malt.

The air of the jar was now examined, and found to consist of

1. *Azotic*, and,
2. *Carbonic acid gas*, or fixed air,

in the proportion of twenty of the former to six of the latter; so that the whole of the *oxygen gas* must have been either absorbed, by the vegetable, or converted into carbonic acid gas.

EXPERIMENT II.

June 19th, 1797, a quantity of barley, treated as in the last experiment, was introduced into a jar containing, instead of common air, the pure *oxygen air*.

At the end of *three* days only it began to grow, and this process went on favourably to the 29th.

The water had now risen considerably in the jar, and the gas had suffered a diminution of one third.

The barley being now withdrawn smelled completely maltish, and tasted sweet.

The gas in the jar, upon examination, proved to be,

1. *Carbonic acid gas,* or fixed air,
2. *Oxygen gas*;

in the proportion of sixty-four parts of the former to four of the latter.

EXPERIMENT III.

January 23d, a quantity of barley, soaked in water for two days, was introduced into a jar containing only forty-six measures of pure *oxygen gas.*

At the end of *three* days the barley began to grow, but soon after the vegetation ceased, and the column of air underwent no apparent diminution; when the air in the jar was examined, it was found to be,

1. *Carbonic acid air,*
2. *Oxygen air*;

of the last not one part even out of the forty-six remained, and the barley was only partly converted into malt, the quantity of *oxygen gas* being insufficient to influence the whole.

EXPERIMENT IV.

Another experiment with *common air* was made at the same time, and exactly under similar circumstances.

In this case the barley did not begin to vegetate until the *end* of the

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[*] The indulgent reader will please to run his pen over an error of the press in the last page, which should have been 52 instead of 40; or, the sense will readily enough obviate any inconvenience from this accidental oversight.

fourth day; and at the period of investigation, which was the same as the last, had made much less progress than in the oxygen gas.

The air in the jar being examined, it was found to contain,

1. *Azotic gas,*
2. *Carbonic acid gas;*

nearly in the proportion of one to two, mixed with a small quantity of oxygen gas, and but little of the barley tasted sweet.

Being now satisfied that, during the evolution of the saccharine principle from vegetable mucilage, a quantity of oxygen was either absorbed or converted into carbonic acid, we wished to know if this process could take place in any degree without the presence of this gas.

In order to determine this point, the following experiments were made.

EXPERIMENT V.

January 20th, a quantity of barley, soaked as in the former experiments, was introduced into a jar filled with and inverted over *mercury.*

At the expiration of 12 days a very considerable quantity of gas was produced, at least five or six times the bulk of the barley; but *nothing like vegetation was perceived.*

The gas, on examination, was found to consist of *carbonic acid,* being entirely absorbed by lime-water.

The barley had not the *least sweet taste,* nor did it appear to have undergone any sensible change.

EXPERIMENT VI.

On January 20th, another portion of the same soaked barley was introduced into a wine glass, and placed in a jar containing *nitrous gas,** inverted over water.

At the expiration of 10 days the gas had undergone a slight diminution, but there was not the smallest appearance of vegetation.

The barley being withdrawn and examined, was found to have undergone no apparent change.

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* An account of the nature and formation of nitrous gas is given in note * page 56.

The gas contained about 1-9th of its bulk of carbonic acid, the remainder being pure nitrous gas, as was manifest from the diminution it underwent when mixed with pure air.

The nitrous gas which disappeared in this instance must have been absorbed either by the barley or the water; the carbonic acid which was found mixed with it, is accounted for by the last experiment.

EXPERIMENT VII. AND VIII.

Two other portions of soaked barley were introduced into jars, the one containing *hydrogenous*,* and the other *azotic gas*, and these were inverted over mercury.

At the expiration of 12 or 14 days there was not the least appearance of vegetation in either, but the gas in both had increased in bulk about 1-5th. The barley being withdrawn and examined, that in the hydrogenous gas tasted musty, but not in the *least sweet*; the portion in the azote appeared to have undergone no change.

The gas in both jars contained from 1-3d to 1-4th of its bulk of *carbonic acid*, the remainder being the original gases not sensibly changed.

CONCLUSION FROM THESE EXPERIMENTS.

From these experiments, therefore, it is manifest that *oxygen* is absolutely necessary for the conversion of vegetable mucilage into sugar, the food of the embryo; as in no one instance was saccharine matter formed where this was not present, and the quantity of the former was always in proportion to that of the latter; for we found in all our experiments, that when the oxygen was consumed this process immediately ceased, and that its quickness was in proportion to the oxygen present.†

In the year 1789 the late Dr. INGENHOUSZ made the following experiments, with a view to ascertain *what species*, or *mixture of airs*, was *most favourable* to the *growth of seeds*.

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* For the nature and production of hydrogen gas see note * page 56.

† The above-related experiments were made by my very ingenious friend Mr. CRUICKSHANK, chemist to the Ordnance.

December 1st this great experimental philosopher put into the window of his chamber several islands made of cork, cut into the shape of a crown, and covered with blotting-paper floating in water, on which were sown *creſs-ſeed.* The heat of the room was 13 degrees of Reaumur.

EXPERIMENT IX.

One of these floating islands was placed under a glass bell containing twelve cubic inches of *inflammable air* (HYDROGEN AIR), extracted "from *iron,*" by adding to it the vitriolic acid.*

EXPERIMENT X.

A second was enclosed in *air corrupted by breathing.*†

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* *Inflammable air* was the discovery of Dr. Priestley. He poured the *diluted* vitriolic acid upon iron filings, or nails, and immediately a dissolution of the iron took place, bubbles of air were engendered, and these being caught, were found to have peculiar characteristic marks. An animal being placed in this air died convulsed, a candle became extinct, and being found 15 times lighter than atmospheric air, it was soon employed in the formation of *balloons,* which in this age has, alas! realized the fable Icarus.

Where were ye, SYLPHS? when on the ethereal main
Young *Rosiere* launch'd, and call'd your aid in vain?
Fair mounts the light balloon, by Zephyr driven,
Parts the thin clouds, and sails along the heaven;
Higher and yet higher the expanding bubble flies,
Lights with quick flash, and bursts amid the skies.—
Headlong HE rushes through the affrighted air
With limbs distorted, and dishevel'd hair,
Whirls round and round, the flying crowd alarms,
And death receives him in his sable arms!

DARWIN.

This air is called *inflammable,* although *per se,* it extinguishes flame, from this circumstance alone, that, when lighted, it burns when in contact with common air, and mixed with a proportion of oxygen, so rapid is the combustion, that it takes fire at once, and explodes with a noise resembling a cannon. Some *inflammable air* blown under soap-suds, a lighted bougie being applied to them, makes so loud a noise, that it seems absolutely to crack, as the common phrase is, the very drum of the ear.—The reader has before learnt, that *light* and *heat* alone proceed from *oxygen air.* In the mode above related of procuring this air, it neither proceeds from the "*iron,*" or the vitriolic acid, but from the *water* which has been added to the last; for no air can, in fact, be produced from concentrated vitriolic acid poured upon iron. The theory of this experiment then is as follows. VITRIOLIC ACID is *sulphur* and *oxygen.* IRON is a simple or uncompounded body. WATER is a compound of *hydrogen* and *oxygen.* Now, when these are mixed, the *oxygen* of the vitriolic acid and of the water, having a greater affinity for the iron than for the sulphur or the hydrogen, deserts both these, and unites with the iron; and the *hydrogen* being liberated and rarefied by the *caloric* produced in this experiment, hence it assumes an aerial form, or the condition of *hydrogen air.*

† This was a mixture of azotic air and fixed air, with a small proportion of atmospheric air; for

EXPERIMENT XI.

A third was surrounded by *hydrogen air,* to which was added a portion of *oxygen air.*

EXPERIMENT XII.

A fourth was in *hydrogen air,* to which was added only a portion of *common atmoſpheric air.*

EXPERIMENT XIII. AND XIV.

The same thing was done by the *air corrupted by breathing* as in the two last experiments.

EXPERIMENT XV.

A seventh was placed in *common air.*

EXPERIMENT XVI.

And the last was in *oxygen air* of 300* degrees of purity.

the air passing over the ramification of the blood-vessels in the lungs is decomposed. Oxygen air is absorbed by the blood, and at each expiration there is fixed air thrown out with water, and the residuary azot, which acts chiefly as a vehicle or alloy to the oxygen air, which now passes into the blood.

* The degree of goodness of any air is ascertained by means of an instrument called an EUDIOMETER, the invention of Dr. Priestley, which is a long glass tube graduated, containing the air you wish to examine. This is inverted over water, and examined by the means of *nitrous air.* This air was the fortunate discovery of Dr. Priestley, who produced it by pouring the nitrous acid on copper or any other metal, when a dissolution of the metal takes place, and the oxygen of the nitrous acid, uniting with the metal to which it has a greater affinity than for its own base, calcines it, leaving the nitrous air free, which ascends in its aerial form. Now this air, when it meets with oxygen air, from the law of affinity, to which it is subject, quickly unites with it, and is reconverted into the state of nitrous acid. This is, says Dr. Priestley, one of the most astonishing experiments in chemistry. When you pour vitriolic acid on marble you are surprised to find torrents of fixed air issue from the solid body. Here you see two airs occupying considerable bulk, when coming into contact, instead of being as before diaphanous, now assume a red colour, and seize upon and devour each other in such a way, that they soon occupy an inconsiderable space; and one measure of this air will destroy four of oxygen, when it becomes nitrous acid, which is absorbed by the water as it rises up the tube. Nitrous acid attacks no other air than oxygen air, because it has no affinity for any other than this; and hence it discovers the quantity of oxygen air in any given volume of air, and thus becomes the test of the purity of any air which we know to depend upon the quantity of oxygen air it contains.

EXAMINATION OF THE SEEDS.

I. December 20th, The seeds in *inflammable air* were only a little swollen, but did not vegetate.

II. Those enclosed by *air corrupted by breathing* vegetated; but on the 15th of December the plants were of a yellow colour, and had perished before the 20th.

III. When *oxygen air,* or *common air,* were added either to the *inflammable air* or the *air corrupted by breathing,* the seeds grew and flourished in exact proportion to the quantity and purity of the added air. But if only a small portion of either airs were added the plants soon perished.

IV. The seeds in *common air* grew in the ordinary way.

V. But those, on the contrary, surrounded by the *oxygen air* rose the first, appeared uncommonly vigorous, and were much finer and greener plants than any of the others.

EXAMINATION OF THE AIR.

I. No alteration was found in the *inflammable air.*

II. The *respired air* was reduced from 12 to 10½ cubic inches, one inch of which was *fixed air,* and the remainder *azotic.*

III. In Experiments XI. XII. XIII. and XIV. the *oxygen air* had wholly disappeared, and we had remaining the *mephitic airs* in their genuine state.

IV. There remained from Experiment XV. with the *atmospheric air,* 11 cubic inches, one inch of which was found to be *fixed air,* and the remainder *azotic.*

V. In none of these experiments was there a vestige of *oxygen air*, this being partly *absorbed* by the plant, and partly *converted* into *fixed air*.

VI. From the experiment with the *oxygen air* there remained 10 cubic inches; 2 cubic inches were therefore *absorbed*, 3 were converted into *fixed air*, and the residue was *oxygen air*, but reduced to 160 degrees of goodness.

CONCLUSION FROM THESE EXPERIMENTS.

Hence, says Dr. Ingenhousz, we are warranted in this conclusion,

I. That *atmospheric air* is useful to vegetation *only* on account of the *oxygen air* which it contains. And,

II. That the *mephitic airs* are adverse to growth only as not containing in their composition *oxygen air*.

III. That *oxygen air* is not only favourable to the growth of plants, but also still more so than atmospheric air.

IV. That *oxygen air* is the true pabulum of vegetable, as of animal, life.

SECT. XII.

VII. WHETHER OXYGEN IS SUPPLIED TO SEEDS THROUGH ANY OTHER MEDIUM THAN WATER PERCOLATING THE EARTH?

To thy lov'd theme return, my happy muse,
For now, behold, the joyous winter-days
Frosty, succeed; and through the blue serene,
For sight too fine, th' *ethereal nitre* flies;
Killing infectious damps, and the *spent air*
Storing afresh with elemental life....
'Tis *the air* that *feeds* and *animates* our *blood.*
All Nature feels the *renovating* force
Of winter, only to the thoughtless eye
In ruin seen. The frost-concocted glebe
Draws in abundant vegetable soul,
And gathers vigour for the coming year.
Thomson.

The poet, from whose immortal work on the Seasons I have selected my motto, approaches so near to what are styled the *new doctrines* relative to the influence of the atmosphere on the blood,[*] and even on the earth, that I should have been almost inclined to think he had derived his notions from Mayow, the philosopher of the last century, unless they had differed as to the season when this sublime process of Nature is chiefly carried on.

Mayow had taught, that the earth became fruitful from the absorption of nitro-aerial particles, and founds his opinion on the following observations.

" Among the principles of natural things, the *nitro-aerial particles* (which is one of the component parts of nitre,[†] derived to it from the air) hold a preeminent rank, and may justly be styled, *Mercury,* as being a substance the most subtle, agile, ethereal, and the prime instrument of vegetable as of animal life."

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[*] Vide the Philosophy of Medicine, or, Medical Extracts on the Nature of Health and Disease; including the Laws of the Animal Economy, and the Doctrines of *Pneumatic Medicine*, by the Author of this work, in five thick volumes octavo.

[†] It has been computed by the Abbé Fontana, that a pound of *nitre*, calcined in a close vessel, yields 12,000 cubic inches of OXYGEN, or VITAL, AIR. It is singularly curious that a substance of such very humble pretensions as common *nitre* (salt-petre) should possess properties on which hangs the fate of the most powerful empires! Since by chemistry it may either be converted into a fulmi-

" The Peripateticks reckoned two principal elements, namely, *fire* and *air*; for both of which our *nitro-aerial Mercury* may be substituted, as possessing the nature of fire itself, and constituting, moreover, the most active and fermentative part of the air."

" With respect to a second element, namely, the *spirit* of certain chemical writers, I am unable to comprehend what they designate by this being, whom they place as the leader of their band of elements, and call an *exalted spirit,* unless it mean the same as that which results from the fermentation of liquor, which rapidly takes fire, when any lighted body is presented to it, and which I think it better to express by the term *sulphur.*"

" Thirdly, those saline and corrosive parts which remain after the combustion of plants: these more properly come under the denomination of *salts.*"

" Besides these, we have, fourthly, *water*; and, fifthly, *earth.*"

" Of these the *nitro-aerial particles* alone deserve the appellation of *spirit.*"

" The *sulphur* is the next in activity to the nitro-aerial particles, with whom it has a perpetual contest."

" The *salts* possess a passive nature, but are more nearly allied to the nitro-aerial spirit than the sulphur."

" The *water* acts only as a vehicle of the salts and sulphur;"

" And the *earth* gives a proper consistency to the whole."

" Having premised thus much, we come now to the play of these elements."

" At the commencement of spring, the *nitro-aerial Mercury,* from its keen, active, and penetrating nature, and the attractions which invite him, *descends deep into the earth,* and assails in the first place the *sulphur,* which is now firmly combined with the *salts,* and, as it were, entirely engaged in the embraces thereof."

nating engine, to overturn fortified cities, and to enable the garrison to launch out death and destruction on the besiegers: Or, . . . that by a different process, it may be made to pour forth VITAL AIR, that VIVIFYING FLUID diffused through the atmosphere, which breathes in the zephyrs, which whispers in the breeze, and which cheers and supports all animated Nature! . . . Dr. FOTHERGILL.

" The conflict now becomes terrible, and, from the mutual impulses given by each, is stirred up that remarkable effervescence, productive of a certain degree of *mild heat,* by means of which the common mother cherishes, with a vital warmth, the seeds committed to her bosom."

" The *salt,* spectatress of the contest, remains, like a timid mistress, passive, and detached from the embraces of her former lord, now chooses the conqueror, and this new intercourse forms either an *acid* or *nitre*; and the vanquished sulphur, freed from the shackles of the salt and earth, assumes a volatile nature."

" This state of things appears to me," continues Mayow, " exactly suited to vegetation: and we find actually, that, under these circumstances, plants take their greatest increase, and nitre is chiefly produced; and this occurs especially in the *spring season.* For in the winter the nitro-aerial particles, the salts, and sulphur, are bound by ice, as in adamantine chains, and are then incapable of any motion, and vegetables cease to grow."

" From this doctrine we see why the excrements of animals, as also lixivial salts, and even quick-lime, render the earth fruitful."

" For the salino-sulphureous excrements of animals are particularly useful, as effervescing with the nitro-aerial spirit, thereby giving a due warmth to the earth for the cherishing of seeds, when the sulphur becoming liberated, and the salt combining with the nitro-aerial spirit, nitre is generated, which conduces not a little towards the growth of plants."

" This is proved, likewise, by the analysis of vegetable bodies, which contain an *inflammable body* (sulphur) volatile; a *saline body* (an alkali) fixed, not to be dispersed by the greatest heat of the crucible; *water* readily dissipated; and a *nitre* seen by the combustion of plants, many burning with a flame although green, especially the beech, which burns with a bright blaze, and with a crackling noise, the very characteristic of deflagrating nitre."

Evelyn, in his " *Terra, or, A Philosophical Discourse on the Earth, and the Culture and Improvement of it for Vegetation,*" which was read before the Royal Society in the year 1675, the year after Mayow had published his five treatises,* which have made so great a noise in the present

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* Tractatus quinque medico-physici, quorum primus agit de Sal-nitro, et Spiritu Nitro-aereo, secundus de Respiratione, tertius de Respiratione fœtus in utero, et ovo, quartus de Motu Musculari, et spiritibus animalibus, ultimus de Richitide, Studio Joh. Mayow, LL. D. et Medici, necnon Coll. Omn. Anim. in Univ. Oxon. Socii. An. Dom. 1674.

The learned Dr. Beddoes, lecturer on chemistry at Oxford, was the first who held up the merits day, says, when discoursing "on the advantage of *fallowing*, of which Virgil speaks so highly,"

> "Illa seges demum votis respondet avari
> Agricolæ, bis quæ solem, bis frigora sensit
> Illius immensæ ruperunt horrea messes."
>
> Georg. II.

> "That crop rewards the greedy peasant's pains
> Which twice the sun, and twice the cold, sustains,
> And bursts the crowded barns with more than promised gains!"

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of Mayow to the literary world. The analysis which he gave was, however, very hastily performed. His other important avocations hurried him too much in detailing "the opinions of the philosopher of the last century;" and, in a public letter to Dr. Yeats, he candidly acknowledges that this work was written in too cursory a manner. Dr. Scherer, of Vienna, and De la Metherie in France, next attempted to enlighten their country respecting the merits of Mayow. Dr. Yeats, of Hertford College, Oxford, afterwards wished to give the public a fuller account of this extraordinary man. A work was undertaken by him for that purpose, entitled, "Observations on the Claims of the Moderns to some late Discoveries in Chemistry and Physiology," to shew how far the recent discoveries in these branches of science were entitled to Novelty. "I have long," says this gentleman, "accustomed myself to, and been peculiarly delighted with, reading the works of the last century; an age distinguished for the productions of many learned men in every department of science. Little did I imagine, at first, that such employment would be the subject of publication; and as little did I conceive, that I should trace out facts supposed to be but very recently discovered. I could not be surprised, too, when I observed theories, founded upon these facts, very similar to those we now entertain. I mentioned them, during conversation, in the philosophical circles which I had the pleasure to attend during my residence in London. Some believed, more disbelieved, and many supposed, that from the glow of conversation, exaggeration might creep in. Having collected a sufficient number of proofs to justify my observations, I imagined they would afford an hour of entertainment to the curious reader."

"It is a source, too, of rational and agreeable amusement to the cultivated mind to examine the similarity of opinions, in distant periods, and to trace the progress of science. It is curious to observe the co-incidence that sometimes takes place between the philosophical systems of great men. As researches into nature ever afford a pleasing employment to rational minds, and as her operations are all directed by fixed and immutable laws, it is not inconsistent to expect, that even in periods the most distant from each other, the philosophical pursuits of the literary will converge to the same point. The same observations, with respect to facts, have, no doubt, repeatedly occurred to every inquirer; and results, which arise from the consideration of general principles, have presented themselves, in a similar point of view, to the examination of philosophers. But it is not a loose *hint* thrown out, nor a system founded upon *conjectural* philosophy, that entitles a man to the merit of a *discoverer*. An arrangement of facts, the result of experimental inquiry and close reasoning alone, claims that honourable appellation. Laborious, indeed, is the investigation which requires it, and tedious the course. How carefully, therefore, ought we to avoid wresting from the brow of a *discoverer* the dear-bought crown of literary fame. It affords a grateful pleasure to a feeling mind to observe each man possessing the rewards due to his labours, and, however difficult it is, to award the *suum cuique*; yet investigation, under almost every circumstance, contributes to that end, and promotes the dispensation of distributive justice."

Coinciding perfectly with Dr. Yeats in this just sentiment, yet I cannot help differing from him in the opinion he entertains for Mayow, who appears to me, judged by this canon, rather to have *approximated* to the truth by the sagacity of a penetrating genius, than actually to have *discovered* it. I fear, likewise, he borrowed much from Hook, which will be shewn hereafter.

" There are, I confess, who fancy that this long exposure of earth, before it come into employ, causes it to exhale the little virtue it already possessed; but, provided nothing be suffered to grow on it whilst it lies fallow, there is no danger of this, for, in fact, *no compost* or *lætation* whatever is comparable to the influences of the heavens, which does, in a great measure, fertilize the earth alone. For, verily, it is almost a miracle to see how the same land, without any other manure or culture, which before was almost effete, will bring forth and even luxuriate, and that by the bare raking and combing of the earth, now one way, and then another, as to the regions of heaven and polar aspects, which is indeed a secret worthy to be considered."

" Take," says he, " the most barren earth you can find, drained, if you please, of all its nitrous salts and masculine parts; reduce it to a fine powder (which may be done even in large proportions, by a rude engine, letting fall a kind of hammer or beetle at the motion of a wheel); let this pulverised earth, which may be frequently agitated, be exposed for a summer and winter to the vicissitudes and changes of the seasons, and influences of the heavens; by this labour, and rest from vegetation, you will find it to have obtained such a generous and masculine pregnancy within that period as to make good your highest expectation; for the earth has a certain *magnetism* in it, by which it attracts the salt, power, or virtue, call it what you please, which gives it life, and is explanatory of the reason of the ploughing, digging, and the advantages arising from incessant labour, confirming the old proverb,"

" Annus fructificat non tellus;"

" for the earth, when once impregnated with the influences of the heavens, becomes so fitted for vegetation, that it receives the seeds committed to its bosom with a passion and fervency, as it were, of animal love."

Sir Kenelm Digby, in his discourse on *Sympathetic Powders*, affirms, " that the earth, in the years of repose, recovers its vigour by the attraction of the vital spirits which it receives from the air, and those superior irradiations which endow simple earth with qualities productive of fermentation."

To this belongs Sir Hugh Platt's contrition, or philosophical sifting of earth, " which, by this process alone, without manure of soil, will in time create a rich, mellow earth, fitted to receive every plant, even from the farthest Indies, and cause all vegetables to prosper in a most exalted degree," and, to speak as magnificently as the illustrious author, " occasion them to thrive as kindly with us as in their natural climate;" and this Dr. Bunting affirms to have himself accomplished."

" That by the air," continues Evelyn, " the moist effete and elixiviated mould comes to be repaired, and is qualified to attract the prolific nitrous spirit (which converts her inactive salts into quite another genius and nature, and, invading the sulphur, stirs up an intestine fermentation, which gives life, and growth, and motion, to all she produces), the learned Dr. Mayow has very ingeniously made out; and all this by a naked exposure of the earth to the air alone, without which it produces nothing."

" Nor can plants, totally excluded from the air, live, or so much as erect themselves to any thriving purpose, as being deprived of that breath and vital balm which no less contributes to their *growth* and nourishment, than does the earth itself with all our foreign assistances."

We cannot help here remarking, that although we must admire the sagacity of our ancestors, who thus, by mere observation of natural phenomena, wonderfully approached those truths which the most accurate experimental analysis has at this day demonstrated, yet must we confess, that the merit of actual *discovery* is more properly due to philosophers of the present times; for it is one thing to *conjecture,* and a very different to *demonstrate.*

The honour, therefore, of really proving the *fecundating property* of VITAL AIR, *as absorbed by the earth,* is due to my worthy and much-lamented friend Dr. Ingenhousz.

EXPERIMENT I.

" I put," says this philosopher, " under a bell, containing forty-six cubic inches of common air, some garden mould, and I exposed this, in a suitable apparatus, from six at night to the same hour the next day, and I found the air *reduced* below 12 degrees of the quality of common air."

EXPERIMENT II.

" At nine o'clock in the morning I put under a bell-glass, containing 100 inches of common air, four plants of the mint kind, very vigorous, and growing in a pot filled with garden-mould, and, examining the air at six in the evening, I found it *degraded* from 99 to 93 degrees."

EXPERIMENT III.

"But if the earth, instead of being mould, is a quartous sand well washed, no such corruption was observed to take place."

EXPERIMENT IV.

"This same plant, being divested of all earth adhering to its roots, enclosed for the same period in atmospheric air, instead of diminishing its oxygen, was found to have increased it to a very considerable degree."

CONCLUSION.

Hence we may conclude, that the surrounding atmosphere is continually decomposed by the earth, and that the VITAL AIR imbibed into it is one of the chief agents of Nature in the process of vegetation.

SECT. XIII.

VIII. ON THE FERTILIZING POWER OF SNOW.

Oh! may'ſt thou often see
Thy furrows whitened by the woolly rain;
Nutritious, secret NITRE lurks within
The porous wet, quick'ning the languid glebe.
PHILIPS.

In the new, or French Calendar you find the months Brumaire (our November), Frimaire (December), Nivose (January), Pluviose (February), and Ventose* (March), succeed each other, all converging to one point, namely, the *oxygenation* of the land, as we shall endeavour to prove.

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*THE FRENCH CALENDAR.

Vendemaire, the *Vintage*, 1ſt. answering to our	September 22, to
Brumaire, *Fog*	October 22, to
Frimaire, 1. *Frost*	November 21, to
Nivose, 1. *Snow*	December 21, to
Pluviose, *Rain*	January 20, to
Ventose, 1. *Wind*	February 19, to
Germinal, 1. *Budding*	March 21, to
Floreal, 1. *Flowers*	April 20, to
Prairial, *Hay-harvest*	May 20, to
Messidor, *Corn-harvest*	June 19, to
Thermidor, *Intense Heat*	July 19, to
Fructidor, *Fruit*	Auguſt 18, to September 22.

A NEW ENGLISH CALENDAR.

The Months of our Calendar might be thus expressed.

I. The *Foggy* Month, NOVEMBER.

Lord, how thy wonders are display'd,
Where'er I turn mine eye!
If I survey the ground I tread,
Or gaze upon the sky!

There's not a plant or flow'r below,
But makes thy glories known;
And *clouds* arise, and tempeſts blow,
By order from thy throne.

We shall not now particularly consider, how the earth is moistened by the dews of our November, and thus the rains sink deep and remain in the earth;

II. *Frosty* Month, December.

Oh *Winter!* ruler of th' inverted year,
Thy scatter'd hair is with frost like ashes fill'd,
Thy breath congeal'd upon thy lips, thy cheeks
Fring'd with a beard made white with other snows
Than those of age; thy forehead wrapt in clouds;
A leafless branch thy sceptre; and thy throne
A sliding car indebted to no wheels,
But urg'd by storms along its slipp'ry way.

III. *Snowy* Month, January.

In winter awful thou! with clouds and ſtorms
Around thee thrown, tempest o'er tempest rolls
Majestic darkness! On the whirlwind's wing
Riding sublime thou bidst the world adore,
And humblest nature with thy *northern blast*.

IV. *Thawing* Month, February.

Reviving nature seems again to breathe,
As loosen'd from the cold embrace of death.

V. *Windy* Month, March.

............For conflict dreadful!
The West encounters East, and Notus meets
In his career the Hyperborean blast.
The lordly lions shuddering seek their dens,
And fly like timorous deer; the king of birds,
Who dar'd the solar ray, is weak of wing,
And faints, and falls, and dies; while HE supreme
Stands stedfast in the centre of the *storm*.

VI. *Showery* Month, April.

How fine has the day been, how bright was the sun,
How lovely and joyful the course that he run,
Though he rose in a mist when his race he begun,
And there follow'd some *droppings of rain!*

VII. *Budding* Month, May.

........Forth in the pleasing *spring*
Thy beauty walks, thy tenderness and love.
Wide flush the fields; the soft'ning air is balm;
Echo the mountains round; the forest smiles;
And every sense, and every heart, is joy.

VIII. *Flowering* Month, June.

All that is *sweet* to smell, all that charm
Or eye or ear, bursts forth on every side,
And crowds upon the senses.

and how afterwards the frost succeeds in December, and turns this water into ice, which would destroy, in great measure, the seeds and plants in the bowels of the earth, unless Nature had, in the same or following month, kindly

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This might be also called the *mowing* Month.

When the fresh spring in all her state is crown'd,
And high luxuriant grass o'erspreads the ground,
The labourer with a bending scythe is seen
Throwing the surface of the waving green;
Of all her native pride disrobes the land,
And meads lays waste before his sweeping hand;
While with the mountain sun the meadow glows,
And fading herbage round he loosely throws,
Then next into his hands the fork he takes,
And ruddy damsels ply their wooden rakes.

IX. *Ripening* Month, JULY.

Berries and pulpous fruits of various kinds,
The promise of the blooming spring, now *yield*
Their rich and wholesome juices, meant t' allay
The ferment of the bilious blood.

X. *Reaping* Month, AUGUST.

Pour'd from the villages, a numerous train
Now spreads o'er all the fields. In form'd array
The *reapers* move, nor shrink from heat or toil,
By emulation urg'd. Others dispers'd,
Or bind in sheaves, or load or guide the wain
That tinkles as it passes. Far behind
Old age and infancy with careful hand
Pick up each straggling ear.

XI. *Sowing* Month, SEPTEMBER.

Arise, ye winds, 'tis now your time to blow,
And aid the work of Nature. On your wings
The *pregnant seeds* convey'd shall plant a race
Far from their native soil.

XII. *Shedding* Month, OCTOBER.

How sweetly Nature strikes the ravish'd eye
Thro' the fine veil with which she oft conceals
Her charms in part, as conscious of *decay*.

MYSTERIOUS ROUND! what skill, what force divine,
Deep-felt in these appear! a simple train,
Yet so delightful mix'd, with such kind art,
Such beauty and beneficence combin'd;

thrown over them a fleecy mantle, which serves as a *defence* against the piercing cold, snow being a bad conductor of heat. For the earth has always produced from the jar of its elements an internal heat, whose temperature at a sufficient depth is found to be equal to 48 of Fahrenheit's thermometer.

Hence a continual contest between the heat of the earth and the snow, the result of which is carrying the temperature to the intermediate point between this and the freezing point.

The object, however, of the present section is to prove that *ice,* or what is the same, *snow,* has its fertilizing power from its possessing a superabundance of *oxygen,* which it imparts to the earth.

Dr. Grew, in his discourse on the nature of snow observes, " that many parts thereof are of a regular figure, for the most part, being, as it were, so many little stars of perfect ice; upon each of which are set other collateral points at the same angles, as the main points themselves; among these are divers other irregular, which are chiefly broken points or fragments of the regular ones; others also by various winds, seem to have been thawed, and frozen again into irregular clusters, so that it seems as if the whole body of snow was one entire mass of icicles irregularly figured; that is, a cloud of vapours being gathered into drops, the said drops do forthwith descend; and in their descent meeting with a freezing air, as they pass through a cold region, each drop is immediately frozen into an icicle, shooting itself into several points; but still continuing to descend, and meeting with some intermitting gales of warmer air, or by their being continually wafted to and fro, touching upon one another, some are a little thawed, blunted, and again frozen into clusters, or entangled, so as to fall into what we call flakes, although in reality snow is firm ice, and the lightness of it is owing only to the excess of its surface, in comparison to the contained matter, as a guinea can be so extended in surface as to ride upon the smallest breath of air."

And all so forming an harmonious whole,
Shade unperceiv'd, so softening into shade;
That as they still succeed, they ravish still.
But wandering oft, with rude inconscious gaze,
Man marks not thee, marks not the mighty hand
That, ever busy, wheels the silent spheres;
Works in the secret deep; shoots, streaming, thence
The fair profusion that o'erspreads the spring;
Flings from the sun direct the flaming day;
Feeds ev'ry creature; hurls the tempest forth,
And, as on earth this grateful change revolves,
With transport touches all the springs of life.

Thomson.

But besides the influence of snow as a guard, it is supposed, says Miller, in his Gardener's Dictionary, to abound with "*salific*" and "*fertile particles*."

Snow, says Evelyn, is to be reckoned among the manures, as containing a quantity of "nitrous particles," which is the *oxygen* of modern philosophy. The motto we have selected is a further corroboration of the prevalence of this notion.

Nor is this conclusion far from the truth, since the latest experiments, and most remarkable discoveries, which have contributed in the highest degree to the rapid progress of physics, have *proved* that snow and ice are waters possessing an high degree of oxygenation.

Hassenfratz being engaged in the examination of the nature of snow, found, when comparing this with rain water, a striking difference, which arose from the superior oxygenation of the snow.

"I put," says this philosopher, "1000 grammes * of snow in a jar, and the same quantity of distilled water in another.

"I poured upon each of the jars an equal quantity of the same solution of turnsole.

"I placed both jars in a warm temperature, and after the snow melted, I remarked that the tincture was redder in the snow water than in the distilled water.

"I repeated this experiment, and with the same result.

"I next put into a jar 1000 grammes of distilled water, and into another the same of snow.

"In each of these jars I put 6·5 grammes of very pure and clean sulphat of iron.

"In the first there was precipitated 0·150 of a gramme of the oxyd of iron, and 0·010 of a gramme in the other.

"As the oxyd of iron is precipitated from a solution of sulphat of iron solely by the quantity of oxygen, which meets it, and as the tincture of turnsole is reddened from the same cause, hence it follows that *snow* contains more oxygen than rain water."

Now a very considerable number of the plants which we have the art of appropriating for our nourishment, are sown in the month of Vendemaire,

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* A gramme is equal to 15·4457 grains Troy.

Brumaire, and even Frimaire (from the month of September to the latter end of December), and the seeds thus abandoned and exposed to an inclement season are soon after sheltered by the snows, which cover them, and when it melts, they are then acted upon by a *superoxygenated* water, which has a powerful operation on them, and greatly hastens on the principle of germination. The Lapland year is very remarkable.

THE LAPLAND CALENDAR.

June	23.	*Snow melts.*
July	1.	*Snow gone.*
	9.	Fields quite green.
	17.	Plants in full blow.
August	2.	Fruits ripe.
	10.	Plants shed their seed.
	18.	*Snow.*

From this time to June 23d, *snow* and *ice*.

So that, by this account, plants, from the coming out of the ground to the ripening of their seeds, take but a month, and the spring, summer, and autumn, are crowded into the space of fifty-six days.

The astonishing progress of the Siberian, or Lapland year, is finely depicted by Beattie, and certainly must in part be ascribed to the fertilizing influence of melted snow.

> Lo! on the chill LAPPONIAN's dreary land,
> For many a long month lost in *snow* profound,
> When Sol from Cancer sends the season bland,
> And in northern cave the storms hath bound,
> From silent mountains, straight with startling sound,
> Torrents are hurl'd, green hills emerge, and soon
> The trees with foliage, cliffs with flowers are crown'd;
> Pure rills through vales of verdure warbling go;
> And wonder, love, and joy, the peasant's heart o'erflow.
>
> BEATTIE.

SECT. XIV.

IX. OF THE UTILITY OF WINDS.

Sylphs! your light troops the tropic winds confine,
And guide their streaming arrows to the line;
While in warm floods ecliptic breezes rise,
And sink with wings benumb'd in colder skies.
You bid monsoons on Indian seas reside,
And veer, as moves the sun, the airy tide;
While southern gales o'er western ocean roll,
And Eurus steels his ice-winds from the pole.

Darwin.

Having discoursed on the months Frimaire and Nivose (December and January), marked by ice and snow, which we have shewn to be highly *oxygenated* waters, we are arrived next at the month, February, which, in our new English Calendar, we have designated by the *Thawing Month.*

In this month the sun occasionally bursts out and melts the ice and snow covering the earth, which circumstance is thus beautifully described by our first of English poets:

.....When white winter o'er the shivering clime
Drives the still snow, or showers the silver rime;
As the lone shepherd o'er the dazzling rocks
Prints his steep step, and guides his vagrant flocks;
Views the green holly veil'd in network nice,
Her vernal clusters twinkling in the ice;
Admires the lucid vales, and slumbering floods,
Fantastic cataracts, and crystal woods,
Transparent towns, with seas of snow between,
And eyes with transport the refulgent scene:....

If breaks the sun-shine o'er the spangled trees,
Or flits on tepid wing the western breeze,
In liquid dews descends the transient glare,
And all the glittering pageant melts in air.

DARWIN.

The glebe being resolved, the month next in succession is Ventose (March), or, in our New English Calendar, the *Windy Month.*

The air being at this time compressed by cold, a greater quantity of *oxygen* is found in a given volume, and the winds act as a kind of bellows to the earth.

Thus more *oxygen* is absorbed by the land, and the beneficial process of *oxygenation* is still further carried on.

SECT. XV.

X. WHY RAIN PROMOTES GERMINATION MORE THAN SPRING OR RIVER WATER?

AQUATIC NYMPHS! you lead, with viewless march,
The winged vapours up the aerial arch,
On each broad cloud a thousand sails expand,
And steer the shadowy *treasure* o'er the land,
Through vernal clouds the gathering drops diffuse,
Plunge in soft rain, or sink in silver dews.

DARWIN.

THE irregular showers of April (the month *Pluviose* of the new Calendar) is a benevolent contrivance of Nature to bring into action the seeds committed to the bosom of the earth.

The farmer and gardener deriving their water from springs and rivers, have in vain tried to imitate these fecundating showers.

The reason of the great fertilizing power of rain is the discovery of modern philosophy.

From the experiments of HASSENFRATZ it appears that, under an exhausted receiver, rain-water suffers air to escape from it, and, upon examination, this air contains a greater proportion of *oxygen* than either river water, spring water, or even atmospheric air.

For atmospheric air exposed to the action of phosphorus, without the application of heat, after the method indicated by Berthollet, is diminished 21 degrees; that is to say, the phosphorus* takes 21 parts of oxygen out of 100 parts of atmospheric air.

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* The theory of this experiment is as follows. *Phosphorus* is a simple body. *Air* is composed of oxygen air and azotic air. The *phosphorus* coming into contact with *common air* obeys the laws of elective attraction, and it unites with the *oxygen* of the atmosphere, *heat* and *light* are liberated, and the *phosphorus* is converted into *phosphoric acid*, a concrete body, accounting for the disappearance of the *oxygen air*. Hence its use, as well as nitrous air, to ascertain the quantity of *oxygen* in any given quantity of air.

Air drawn from the water of the Seine, tried by the same eudiometer, gave nearly the same diminution.

Air drawn from rain-water was, on the other hand, diminished by phosphorus from 32 to 40 degrees.

As the mean of a great number of experiments was 35 degrees, it thence follows that the proportion of oxygen in the air obtained from rain-water, newly fallen, is greater and more considerable than that contained in atmospheric air, and in the air of other waters.

Sir FRANCIS FORD discovered, that seeds germinated much sooner, and became more vigorous, when he moistened the pot containing them with water impregnated with oxygen air[*].

Since rain-water thus differs from pump and other waters by the quantity of *oxygen* held in solution, and since oxygen has so great an influence on germination and on vegetation, as is proved by the experiments of INGENHOUSZ, SENEBIER, and Sir FRANCIS FORD, it is but just to ascribe to it a part of the peculiar action which *rain* has on the vegetation of plants different from that of other water with which they may be supplied.

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[*] The manner water is impregnated with oxygen air is as follows. The pump, or river water, must be first boiled, which forces out the atmospheric air from the interstices of the water, and being afterwards placed in contact with the *oxygen air*, as it cools, it imbibes this enlivening principle.

SECT. XVI.

XI. ON THE POWER OF CERTAIN OXYGENATED SUBSTANCES TO ACCELERATE THE PROCESS OF GERMINATION.

Hence in fine Streams diffusive *Acids* flow.

DARWIN.

As all the Acids resemble each other in their taste; in their giving a red colour to litmus, and other blue vegetable substances; in their tendency to coalesce with alkalies, and metallic bodies; the immortal MAYOW[*] first proclaimed to the world, that they must possess some *common principle*; and chemical analysis, advanced as it is at the present day, has put this opinion beyond the possibility of a doubt.

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[*] De acidorum ortu, Ch. iv. or vide an Analysis of Mayow's work by the celebrated Dr. Beddoes, who has the honour of first bringing into light the merit of him, whom he has justly styled the "Philosopher of the last century." For some time, says Dr. Beddoes, though I had often tried to procure for myself Mayow's five Treatises, I had only been able to see them within the precincts of a college library, so scarce is his publication, and should I ask, who of all our acquaintance, is the person least likely to be overtaken by surprize, you would, I think, name a certain northern professor (Dr. *Black*), to whom both of us owe great obligations, yet at the sight of the plates, representing Mayow's chemical apparatus, this sedate philosopher lifted up his hands in complete astonishment. I have deduced, adds Dr. Beddoes, as well as I can, the history of Mayow's writings to our own times. Henceforward, I flatter myself, that he will share the glory of VERULAM and NEWTON, and be named with due respect by all, by those especially who have perused his work; and that when the enthusiasm of an Englishman salutes his country, as

Magna parens frugum!——
Magna virum!——

MAYOW will be ranked among the foremost of her illustrious men. He continues with his usual candour, Should any one now inquire, in the simplicity of his heart,—for if the question were dictated by any other spirit, I should bid the inquirer seek information for himself,—whether the name of honour, due to the *moderns*, is to be found by subtracting the share of MAYOW, let him be assured, *that the discoveries of our times set out from a different point, and proceeded in a different train, in perfect ignorance of him, and therefore without any assistance from him.*

The philosopher of the last century even went so far as to declare this *common principle* to be the " NITRO-AERIAL PARTICLES" (the *oxygen* of modern times) which unite with different bases, and thus constitute the several acids.

In his fourth chapter, " on the origin of acids," we see him combating the received opinion, " denying that the vitriolic acid is contained in Sulphur before deflagration."

He attributes " its change to the affinity its base has for the *nitro-aerial particles*, which convert the sulphur into sharp sword-like atoms, giving them the poignancy which constitutes the character of an acid."

" If vitriol," says he, " be calcined till the acid be totally expelled, and then exposed to the air, it will be anew impregnated with an acid, by the slow combination of the *nitro-aerial particles* with the sulphur; for it is impossible to conceive in what other way the spirit of vitriol can be regenerated."

" The rust of iron also is produced by the *nitro-aerial particles* attacking the iron; and the effect of exposure to *air* is only a slower process, as if the iron were moistened by some *acid*."

How consonant are these ideas with the doctrines of modern chemistry!

The unfortunate LAVOISIER in a series of Essays* taught his ungrateful countrymen " the composition of the vitriolic, phosphoric, and nitrous acids."

" Many additional experiments," says this Philosopher in Essay VIII. have enabled me to generalise this doctrine, and to pronounce that this *pure* and *highly respirable air* is the constitutive principle of acidity; that this principle is common to all acids; and that the difference by which they are distinguished from each other is produced by the union of one or more principles, besides *this air*, so as to constitute the particular form under which each acid appears."

Having premised thus much respecting the nature and composition of acids, we come now to the consideration of the important experiments of HUMBOLDT, which were made in the year 1793.

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* Vide Essays, or Memoirs, read before the Royal Academy of Sciences, translated by Thomas Henry, F. R. S.

EXPERIMENT I.

This experimentalist first mixed the *oxygenated muriatic acid gas*[*] with water, and CRESSES *(the Lepidium sativum of Linnæus)* were immersed in it, and these shewed signs of germination at the end of *six* hours.

EXPERIMENT II.

The same being treated in a similar manner in common water, did not exhibit their germs until the end of *thirty* hours.

These experiments were made at the temperature of from 57° to 60°.

OBS. The action of the oxygenated water was *immediately* shewn by an enormous quantity of air-bubbles, which covered the surface of the seeds: a phænomenon not exhibited in common air till after *thirty* or *forty* minutes.

EXPERIMENT III.

In the summer of 1796, HUMBOLDT began a new series of experiments, and found that by an increased degree of heat, the *oxygenated water* still more remarkably accelerated the process of germination.

The temperature was raised to 88° of Fahrenheit.

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[*] All acids are combinations of radicals, or acidifiable substances, different in each species, with *oxygen,* which is the same in all: whence it follows, that their *common properties,* their characters as acids, depend on *oxygen;*—their *particular properties,* their *specific characters* arise from their *radicals.*

Each radical may be also contemplated in four states.

1st, As containing very little *oxygen,* not sufficient to impart to it the nature of an acid, and in this it is nothing more than an *oxyd;* such is sulphur coloured red or brown, by exposure to air, and a degree of heat inadequate to produce combustion.

2dly, Containing more *oxygen* than in the preceding case, and enough to become an acid, though weak, when it is called the *sulphureous acid.*

3dly, Possessing still more *oxygen* than in the second instance, and having acquired powerful acid properties, then the termination is not in *ous,* but in *ic,* and it is then styled the *sulphuric acid.*

4thly Conjoined with a still larger dose of *oxygen,* when instead of the last termination, the term *oxygenated* is used.

Thus the character of the *muriatic acid,* gaseous or fluid, is its having a pungent smell, unalterable by any known combustible substance, on the contrary attracting oxygen from several burnt, or oxygenated, bodies, particularly from metallic oxyds, and thus becoming *oxygenated muriatic acid.*

The *oxygenated muriatic acid* is remarkable for these properties, its greenish yellow appearance; its power of divesting vegetable substances of all colour; burning and inflaming most combustible substances; and forming with potash a salt, which rapidly sets fire to heated inflammable substances; and affords the purest *vital air* known.

Equal quantities of GARDEN CRESSES *(Lepidium sativum)* were thrown into the water, mixed with the *oxygenated muriatic acid.*

These exhibited their germs very rapidly in the *oxygenated* water, even in *three* hours.

EXPERIMENT IV.

Whereas those in *common water,* under the same circumstances, did not take place until the end of *twenty-six* hours.

EXPERIMENTS V...VIII.

The same result arose in comparative experiments with PEAS *(Pisum sativum),* FRENCH BEANS *(Phaseolis vulgaris),* GARDEN LETTUCE *(Lactuca sativa),* and MIGNONETTE *(Reseda odorata.)*

EXPERIMENT IX.

The philosophic mind generally pushes forward every new discovery, and we find HUMBOLDT in the same year endeavouring to cause to germinate the CLUSIA ROSEA (*Rose Clusia),* the seeds of which had been brought from the Bahama Islands by Boose, and which before had resisted every attempt to make them vegetate.

For this purpose he employed a new process, which promises hereafter to be a great acquisition for the raising of foreign seeds of difficult growth.

He formed a paste, by covering the seeds with the *black oxyd of Manganese,* and then sprinkled over them the *muriatic acid* diluted in water.*

The temperature was 95° of Fahrenheit.

The theory of this process is as follows....The *oxygen* in the *black oxyd of Manganese,* quits the *metallic body,* to unite with the *muriatic acid,* to which it has a greater affinity, and in consequence it becomes highly *oxygenated muriatic acid.*

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* The proportion used were six measures of water to one of the muriatic acid.

As such it imparts its *oxygen* to the vegetable fibre, and thus accelerates the first actions of life; returning back to its pristine state of simple *muriatic acid.*

EXPERIMENT X.

These interesting experiments have been repeated with great industry by several distinguished philosophers.

Professor Pohl at Dresden caused to germinate in water mixed with the *oxygenated muriatic acid,* the seeds of a new kind of Euphorbia, taken from Bocconi's collection of dried plants, 120 years old, which were supposed through time to have lost their vegetative power.

EXPERIMENT XI...XXX.

Jacquin and Vander Schott at Vienna, threw into the diluted *oxygenated muriatic acid* all the old seeds, which had been kept at the Botanic Garden, after they had been in vain before attempted to be made to germinate, and the greater part of them succeeded.

Among these were the seeds of the nickar tree *(Guclandina bonduc),* the Pigeon Pea *(Cytysus Cajan),* the narrow-leaved Dodonæa *(Dodonæa angustifolia),* the climbing sensitive plant *(Mimosa scandens),* and several new species of the homæa.

EXPERIMENT XXXI.

There are now to be seen at Vienna very many valuable plants, which are entirely arising from the *oxygenated muriatic acid.*

Von Uslar, in his Chemico-Physiological observations on plants, relates that he took different seeds of different plants, and caused an accumulation of *oxygen* in some, while no such accumulation took place in the rest, and found that, under certain circumstances, the first germinated sooner, and grew quicker than the latter.

In order to dispose plants for imbibing more *oxygen,* it is necessary to apply to them bodies, which contain *oxygen* but weakly combined, or from which it is easily separable, and whose basis has less attraction to *oxygen* than the vegetable matter has; and such a body is the *oxygenated muriatic acid.*

This Philosopher sowed the Lepidium Sativum *(garden Cress)* in two different pots; the earth of the one he moistened with *pure river water,* and that of the other with the same kind of water mixed with the super-oxygenated *muriatic acid.*

The seeds in the *latter* germinated much sooner than in the *former,* which was only moistened with pure water, and which consequently could not communicate to the plants so much *oxygen* as the other, and thence too, the plants in it were much retarded in their growth.

EXPERIMENT XXXIII....XXXV.

The results from experiments made with other seeds; for instance, with the field Cabbage *(Brassica campestris),* Turnep *(Brassica napus),* and common Pea *(Pisum sativum),* exactly coincided with the experiment before mentioned.

In order to ascertain in a more satisfactory manner, that the greater proportion of *oxygen* caused the vigorous and quick growth of plants, Von Uslar varied his experiment.

He took pounded quartz instead of earth, and moistened one portion of it with the *superoxygenated acid,* and another portion with *pure water*; and the result was the same as in the former trials.

EXPERIMENT XXXVI...XXXVIII.

If the seeds, says Dr. Hooper, of Pembroke College, Oxford, in his excellent epitome, (entitled, Observations on the Structure and Œconomy of Plants), of Phaseolus, Pisum, and Lepidium, (the *Bean, Pea,* and *Cress)* be put into silicious earth, (powdered flint-stone), and sprinkled with water mixed with a portion of the *oxygenated muriatic acid,* for in no acid does *oxygen* so abound and so laxly adhere, they germinate much sooner than if sprinkled with *pure water.*

EXPERIMENT XXXIX....XLI.

A small portion of *nitre*[*] in water I found, adds this accurate observer of Nature, to cause the Hyacinth, Narcissus, and other bulbous plants, to germinate much sooner than they otherwise would have done.

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[*] The great quantity of *oxygen* contained in nitre is shewn in note (†) page 60.

EXPERIMENT XLII....XLV.

Pursuing the inquiry, Humboldt found that metallic bodies simply did not promote germination, but that metallic *oxyds* favour it, and that, in the exact proportion of the degree of *oxydation** of the metal.

Von Uslar has confirmed these experiments, and observes that, even in the *oxyd of lead* (litharge), he found that plants grew very well, and better indeed than in pure earth.

And the learned Dr. Darwin in his Phytologia† mentions, that he has been creditably informed, that a *red ocher of iron,* called reddle,* has been used on some lands with advantage in the north of Staffordshire.

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* Not only do all metals compared with each other absorb different quantities of *oxygen* to saturate them in their combustion by the contact of air, but each metal considered separately absorbs different proportions, and stops at various points of *oxydation*, according to the degree of temperature to which it is raised. Thus tin, lead, copper, iron, change colour and assume the *tints* of the *rainbow*, at the first degree of fire to which they are exposed in contact with the air; Lead first becomes a *grey oxyd*, next *yellow*, and lastly *red*; Mercury passes from *black* to *white*, from white to *yellow*, and from yellow to *red*; Iron, at first a *black* oxyd, becomes next *green*, then *brown*, and ultimately *white*; Copper is at first a *brown oxyd*, from which it changes to *blue*, and its last degree of *oxydation* imparts to it a *green* colour.

† The Phytologia of this able writer arose from a circular letter sent round by the Board of Agriculture, proposing queries respecting numerous points, relative to the growth and cultivation of plants, and it contains a concise account of all the most important discoveries, that have any connexion with the subject of Botany, and these are so nicely arranged, and digested, with new observations from the author, as to form a work, that may certainly boast of being the first *Philosophic Treatise* upon so interesting a branch of Science. My New Illustration of the Sexual System of Linnæus, was begun long before the appearance of Dr. Darwin's elaborate work, and the plan publicly proposed, and I have to rejoice that our respective performances do not interfere, but must mutually advance each other. Dr. Darwin addresses his readers, as already conversant in botany and adepts in the new chemistry. My work supposes in my readers a total unacquaintance with all kind of chemical and botanical knowledge, and I expatiate on the several subjects I have to treat of, and lead my readers, step by step, from lesser to higher flights, enforcing all the while my instructions, by plates, which from their fine execution, (as is universally allowed,) "may be as a substitute for the plants themselves," which I conceive to be the readiest way of attaining a knowledge of the useful and delightful science of Botany. For, as the great Rousseau justly laments to the Duchess of Portland, in his Letters, "No such work was to be found, in his time, and as plants bloomed at different seasons, and could not always be procured, to acquire a knowledge of Botany from the Book of Nature was a tedious and almost insurmountable attempt." In a few words, my work is chiefly *elementary*, Dr. Darwin's wholly *philosophic*; and I take this opportunity of expressing the great obligations I owe to the Phytologia, as well as to Dr. Darwin's two immortal poems, the Œconomy of Vegetation, and Loves of the Plants, which have so often served to enliven the heads of the several sections, by furnishing an appropriate motto. As an excuse for some liberties taken with the text, vide note *, page 41, I must beg leave to add also, that the notes of the Botanic Garden contain a fund of useful erudition. Indeed, all Dr. Darwin's writings are intrinsically excellent, and superior to my feeble praise.

EXPERIMENT XLVI.

HUMBOLDT made experiments with the *muriatic,*† *nitric,*‡ and *sulphuric acids,*§ pure, and mixed with water, and he found that these produced no sensible effect in promoting germination.

The reason of which appears to be this: The *oxygen* of these acids is too firmly attached to their respective radicals, to be disengaged, and act on the affinities presented them by the vegetable fibre.

CONCLUSION.

Hence we presume, we may be warranted to conclude, that OXYGEN when *combined* with *certain radicals* has a *great effect* in *accelerating the process of germination.* ||

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[*] *Reddle,* or *Red Chalk,* is a calciform ore of iron, termed in the new nomenclature, the *yellow* oxyd of *iron.*

[†] For an account of the *muriatic acid,* vide note (*), page 79.

[‡] The *nitric acid* is liquid, white, caustic, of a strong and nauseous smell, and is formed of *azot* and *oxygen.* The *nitrous acid* is the same as the *nitric acid,* except in having a smaller portion of *oxygen,* and is composed of one part *azot,* to three parts *oxygen,* which was first discovered by the Hon. Mr. Cavendish, who put three parts *oxygen air,* to one of *azot,* into a bell glass, and by passing the *electric fire* through that mixture, caused them to combine, and hence produced the *nitrous acid;* such are the wonderful changes resulting from a new combination of simple elements!

[§] The *sulphuric acid* is formed of *sulphur* and *oxygen,* by the combustion of sulphur; it is inodorous, and twice as heavy as water. The *sulphureous acid* only differs from this in containing less oxygen, but has, on the contrary, a very powerful smell.

[||] This subject will be resumed when we come to treat on the Principles of Agriculture, when we shall relate at length the experiments of Dr. Ingenhousz, who proposed to the Board of Agriculture a scheme of quickly *oxygenating,* by means of *acids,* the earth, to prevent the necessity of *fallowing;* and he obtained the Gracious Permission of THE KING, who has ever with parental solicitude encouraged the *plough,* to try these experiments upon any part of the land cultivated by HIS MAJESTY.

SECT. XVII.

XII. OF THE EARTH'S INTERNAL HEAT.

NYMPHS! your fine forms with steps impassive mock
Earth's vaulted roofs of adamantine rock;
Round her still centre tread the burning soil,
And watch the billowy lavas as they boil;
Where in basaltic caves imprison'd deep,
Reluctant fire in dread suspension sleep;
Or sphere on sphere in widening waves expand,
And glad with GENIAL WARMTH *the incumbent land*
So when the mother-bird selects their food
With curious bill, and feeds her callow brood;
Warmth from her tender heart eternal springs,
And pleased she clasps them with extended wings.
DARWIN.

ALL the heat we meet with here on the earth we are ready at once to ascribe to the action of the sun, overlooking that produced within the earth itself, which we shall in this section attempt to shew to be very considerable.

We learn from the most correct observations, that in the cave of the observatory at Paris, only about 90 feet under ground, the heat keeps the thermometer at 53° of Farhenheit; and this without any assistance from the sun; it being never sensibly increased by the most scorching seasons one degree beyond its heat in the most severe winters that have ever been experienced there.

And the same constant and unalterable degree of heat was observed by the honourable Mr. Boyle in a cave cut deep into the earth.

Great and even troublesome heats are said to have been observed at greater depths, and always increasing in proportion to these depths.

Morinus (de locis subterraneis) relates that in the mines of Hungary, which are 500 cubits deep, the heat becomes very troublesome when the miners get below 480 feet deep.

The accurate Mons. de Luc in going 1359 feet perpendicular in the mines of Hurtz, on July 5, 1778, on a very hot day found the air at the bottom warmer than that at top of the shaff.

Lord Verulam, and others, have remarked the various temperatures of the air in different places of the earth do by no means correspond to what should be the result of their position to the sun.

To omit variations that are small and of less moment, I shall only take notice of the much greater cold in all the southern hemisphere than in those of the same latitude on the European side of the globe.

All which seems to argue a copious fund of some other more potent cause of heat than the regular action of the sun; and that cause is inherent in the earth itself, and is stronger in some regions than in others, though every where considerable and of great force.

Various have been the opinions of philosophers relative to the cause of this phænomenon.

Mons. de Mairon, in a paper published in the Histoire de L'Academie de Sciences, in 1765, has conjectured, that the earth's internal heat must proceed from fires kindled within the earth at its center.—

Firſt, from the warm springs found in many parts of the earth, as Bath, Aix la Chapelle, which have kept the same temperature at all seasons, and through so many centuries.*

Secondly, the frequent eruptions of burning mountains, which have astonished mankind through every age.

Thirdly, the very distant and expeditious communication of the shocks of some great earthquakes.

That of Lisbon in 1755 was perceived even in Scotland and many more distant parts.

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* These *hot springs* are always the same; for the longest and heaviest rains do not cauſe them to give out more water, nor the driest seasons occasion them to discharge less.

These phænomena are easily explained, says the celebrated Dr. Darwin, if we suppose the central part of the earth to consist of a *fluid Lava,** as a percus-

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* The matter which is found to roll down from the mouth of all volcanos in general, resembles the dross that is thrown from a smith's forge. But it is different, perhaps, in various parts of the globe; for, there is not a quarter of the world that has not its volcanoes. In *Asia,* particularly in the islands of the Indian ocean, there are many. One of the most famous is that of Albouras, near mount Taurus, the summit of which is continually on fire, and covers the whole adjacent country with ashes. In the island of Ternate there is a volcano, which, some travellers assert, burns most furiously in the times of the equinoxes, because of the winds which then contribute to increase the flames. In the Molucca islands there are many burning mountains; they are also seen in Japan, and the islands adjacent; and in Java and Sumatra, as well as in other of the Philippine islands. In *Africa* there is a cavern, near Fez, which continually sends forth either smoke or flames. In the Cape de Verde islands, one of them, called the Island del Fuego, continually burns; and the Portugueze, who frequently attempted a settlement there, have as often been obliged to desist. The Peak of Teneriffe is, as every body knows, a volcano that seldom desists from eruptions. But of all parts of the earth, *America* is the place where those dreadful irregularities of nature are the most conspicuous. Vesuvius, and Ætna itself, are but mere fire-works, in comparison to the burning mountains of the Andes; which, as they are the highest mountains of the world, so also are they the most formidable for their eruptions. The mountain of Arequipa in Peru, is one of the most celebrated; Carassa, and Malahallo, are very considerable; but that of Cotopaxi, in the province of Quito, exceeds any thing we have hitherto read or heard of. The mountain of Cotopaxi, as described by Ulloa, (Ulloa, vol. i. p. 442) is more than three miles perpendicular from the sea; and it became a volcano at the time of the Spaniards' first arrival in that country. A new eruption of it happened in the year 1743, having been some days preceded by a continual roaring in its bowels. The sound of one of these mountains is not like that of the volcanoes in Europe, confined often to a province, but is heard at an hundred and fifty miles distance. An aperture was made in the summit of this immense mountain; and three more about equal heights, near the middle of its declivity, which was at that time buried under prodigious masses of snow. The ignited substances ejected on that occasion, mixed with a prodigious quantity of ice and snow, melting amidst the flames, were carried down with such astonishing rapidity, that in an instant the valley from Callo to Latucunga was overflowed; and besides its ravages in bearing down the houses of the Indians, and other poor inhabitants, great numbers of people lost their lives. The river of Latucunga was the channel of this terrible flood; till being too small for receiving such a prodigious current, it overflowed the adjacent country, like a vast lake, near the town, and carried away all the buildings within its reach. The inhabitants retired into a spot of higher ground behind the town, of which those parts which stood within the limits of the current were totally destroyed. The dread of still greater devastations did not subside for three days; during which, the volcano ejected cinders, while torrents of melted ice and snow poured down its sides. The eruption lasted several days, and was accompanied with terrible roarings from its crater, rushing through the volcano still louder than the former rumblings in its bowels. At last all was quiet, neither fire nor smoke to be seen, nor noise to be heard; till, in the ensuing year, the flames again appeared with recruited violence, forcing their passage through several other parts of the mountain, so that in clear nights the flames being reflected by the transparent ice, formed an awfully magnificent illumination."

Such is the appearance and the effect of those fires which proceed from the more *inward recesses* of the earth; for that they generally come from deeper regions than man has hitherto explored, I cannot avoid thinking, contrary to the opinion of BUFFON, who supposes them rooted but a very little way below the bed of the mountain. " We can never suppose," says this great naturalist, " that these substances are ejected from any great distance below, if we only consider the great force already required to fling them up to such vast heights above the mouth of the mountain; if we consider the substances thrown up, which we shall find upon inspection to be the same with those of the mountain below; if we take into our consideration, that air is always necessary to keep up the flame; but, most of all, if we attend to one circumstance, which is, that if these substances were exploded from sion on one part of such a fluid mass would be felt on other parts of its confining vault, like a stroke on a fluid contained in a bladder, which however gentle on one side, is perceptible to the hand placed on the other; and the velocity with which such a concussion would travel would be that of sound, or thirteen miles in a minute.

Hence Dr. Darwin has been led to conjecture in his beautiful poem on the œconomy of vegetation, that the first act of the Almighty was the Creation of innumerable Suns.

> " LET THERE BE LIGHT!" proclaim'd the Almighty Lord. . . .
> *Astonish'd Chaos* heard the potent word;—
> Through all his realms the kindling Ether runs,
> And the mass starts into a million *Suns*.*

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a vast depth below, the same force required to shoot them up so high, would act against the sides of the volcano, and tear the whole mountain in pieces." To all this specious reasoning particular answers might easily be given; as that the length of the funnel increases the force of the explosion; that the sides of the funnel are actually often burst with the great violence of the flame; that air may be supposed at depths at least as far as the perpendicular fissures descend. But the best answer is a well-known fact; namely, that the quantity of matter discharged from Ætna alone, is supposed, upon a moderate computation, to exceed twenty times the original bulk of the mountain. (Kircher, Mund. Subt. vol. i. p. 202.) The greatest part of Sicily seems covered with its eruptions. The inhabitants of Catanea have found, at the distance of several miles, streets and houses, sixty feet deep, overwhelmed by the lava or matter it had discharged. But what is still more remarkable, the walls of these very houses have been built of materials evidently thrown up by the mountain. The inference from all this is very obvious; that the matter thus exploded cannot belong to the mountain itself, otherwise it would have been quickly consumed; it cannot be derived from moderate depths, since its *amazing quantity* evinces, that all the places near the bottom must have long since been exhausted; nor can it have an extensive, and, if I may so call it, a superficial spread, for then the country round would be quickly undermined; it must, therefore, be supplied from the *deeper regions* of the earth; those undiscovered tracts where the Deity performs his wonders in solitude! Vide Goldsmith's History of the Earth, Vol. I. p. 91—96.

* This assemblage of vast bodies is divided into different *systems*, the number of which may perhaps exceed the grains of sand which the sea casts on its shores.

Each system has its center or focus, call it either a fixed star or sun, which shines with its own light, and round which revolve various orders of opaque globes, which reflect with greater or lesser lustre the light they borrow from it, and which renders them visible to us.

These, which seem to wander among the heavenly bodies, are *planets*, the principal of which have what we call *the sun* for the common center of their periodical revolutions; whilst the others, which are styled secondary, move round one principal planet, which they accompany like satellites, in its annual revolution.

Venus and the *Earth* have each of them their satellite. One will undoubtedly be some time or other discovered in *Mars*. *Jupiter* has four, *Saturn* five, and a ring or luminous body which seems to perform the office of a number of small moons. Being situate near three hundred millions of leagues from the sun, he would have received too faint a light from it, if his satellites and ring did not augment it by reflection.

We have discovered *twenty-seven planets*, which at present compose *our solar system*; but we

The planets are next represented to emanate from these suns, and their moons and satellites to be derived from them.

> Gnomes! your bright forms, presiding at her birth,
> Clung in fond squadrons round the new-born *Earth*;
> When high in ether, with explosion dire,
> From the deep craters of his realms of fire,
> The whirling Sun this pond'rous planet hurl'd,
> And gave the astonish'd void another world.
>
> Gnomes! how you gaz'd! when from her wounded side
> Where now the South-Sea heaves its waste of tide,
> Rose on swift wheels the *Moon's* refulgent car,
> Circling the solar orb, a sister star.

The celebrated French Naturalist* represents the Deity as employing a Comet in the work of creation.

This impinging with immense power on the *sun*, just as particles of fire are driven from a flint when struck by a steel, so those bodies which form

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are not certain that there are not more of them. Their number has received a great increase by the invention of telescopes: more perfect instruments, and more assiduous and accurate observers, may probably make some further addition to them. The satellite of Venus, of which there was a discovery made in the last century, and of the *Georgium Sidus* in the present, gives room for astronomers to expect a still greater augmentation of their number.

The diameter of the great orbit, which our planet describes round the Sun, is more than sixty millions of leagues, and this vast circumference vanishes into nothing, and becomes a mere point, when made use of by astronomers to measure the distance of the *fixed stars*.

How great then must be the real bulk of those spotlike stars, that are perceivable by us at such an enormous distance! The sun is about a million times greater than the earth, and an hundred and ten times greater than all the planets put together.

If the stars are *suns*, as their lustre gives us reason to suppose, how greatly must they surpass our earth in size!

The stars, when seen through a teleſcope, are innumerable: their sparkling affords a proof that they shine with their own light; and since they are visible to us at incomparably greater distances than Saturn, we may from thence infer that they are so many *suns*. Our sun, if viewed from a star, would itself appear like a star. There must then be an *infinite number of suns*; and to what purpose would they serve, if there were not Beings capable of enjoying the advantages of their light and heat? Is it not therefore natural to suppose, that they give light to other worlds, which their prodigious distance deprives us of, and possess also their several productions and inhabitants. How transcendent the idea, that these systems are all stored with Beings, created by a God, who wanted no fresh accessions to his happiness!

Thus it is that night conveys to the mind a much grander conception of infinity than the day-time. In the glare of day I behold but one sun; but in the night I discern *myriads*.

The light discovers to me only a terrestrial infinity, but the darkness discloses an infinity altogether *celestial*.

* Buffon. Vide his Theory of the Earth, Vol. I.

our solar system, including the earth, and moons, with the several satellites, broke from the *Sun's substance,* and were scattered over the vast inane.

Being driven with an impulsive force they would have receded for ever, had not God endowed the sun with an attractive power, which, operating as the planets lost something of their direct motion, produced those circumgirations which they now possess.

As the fluid Earth was impelled forward, it rolled round and round, and then obtained its oblate, or spheroid figure, producing the vicissitudes of night and day: and as our globe was once a part of the sun, it still continues at its center to be an uniform mass of melted matter, in its state of primeval fusion.

But its surface is very differently composed.

Having been in the beginning heated to a degree equal to, if not greater, than what comets are found to sustain, most things were in a state of vapour, which subsiding, in proportion as the substance cooled, formed, according to their several densities, earth, water, air; the heavier parts sinking, and the lighter still remaining suspended.

By degrees things took their proper stations.

The waters covering the earth, formed for themselves beds, and mountains rose.*

And the Earth was then, by the Almighty Fiat, to bring forth grass, and the herb yielding seed, and the fruit tree yielding fruit, each after his own kind...next living creatures, cattle, birds, fishes, insects...and lastly, the paragon of creation, Man.

> Next Love Divine, with brooding wings unfurl'd,
> Call'd from the rude abyss the *living world.*
>
> Darwin.

I shall now present my readers with the opinion of the celebrated Dr. Whiston, who supposes " the earth to have been originally not the spark of a sun, but actually a *comet*; and considers the history of the creation, as given us in Scripture, to have its commencement just when it was, by the hand of the CREATOR, more regularly placed as a planet in our solar system.

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* There is something infinitely more simple and grand in the scriptural account of the Almighty being *six days* employed in the *Work of Creation,* than in this slow progress of the Earth towards its perfection.

Before that time, he supposes it to have been a globe without beauty or proportion; a world in disorder; subject to all the vicissitudes which comets endure; some of which have been found, at different times, a thousand times hotter than melted iron; at others, a thousand times colder than ice.

These alterations of heat and cold, continually melting and freezing the surface of the earth, he supposes to have produced, to a certain depth, a chaos entirely similar to that described by the poets, surrounding the solid contents of the earth, which still continued unchanged in the midst, making a great burning globe of more than two thousand leagues in diameter. This surrounding chaos, however, was far from being solid: he resembles it to a dense though fluid atmosphere, composed of substances mingled, agitated, and shocked against each other; and in this disorder he describes the earth to have been just at the eve of creation.

But upon its orbit being then changed, when it was more regularly wheeled round the sun, every thing took its proper place; every part of the surrounding fluid then fell into its situation, in proportion as it was light or heavy.

The middle, or central part, which always remained unchanged, still continued so, retaining a part of that heat which it received in its primeval approaches towards the sun; which heat, he calculates, may continue for about six thousand years!

Next to this fell the heavier parts of the chaotic atmosphere, which serve to sustain the lighter: but as in descending they could not entirely be separated from many watery parts, with which they were intimately mixed, they drew down a part of these also with them; and these could not mount again after the surface of the earth was consolidated: they, therefore, surrounded the heavy first descending parts, in the same manner as these surround the central globe.

Thus the entire body of the earth is composed internally of a great *burning mass*; next which is placed an heavy terrene substance, that encompasses it; round which also is circumfused a body of water.

Upon this body of water the crust of earth on which we inhabit is placed: so that, according to him, the globe is composed of a number of coats, or shells, one within the other, all of different densities.

The body of the earth being thus formed, the air, which is the lightest substance of all, surrounded its surface; and the beams of the sun darting through, produced that light which, we are told, first obeyed the CREATOR's command.

The whole œconomy of the creation being thus adjusted, it only remained to account for the risings and depressions on the surface of the earth, with the other seeming irregularities of its present appearance.

The hills and vallies are considered by him as formed by their pressing upon the internal fluid, which sustains the outward shell of the earth, with greater or less weight: those parts of the earth which are heaviest, sink into the subjacent fluid more deeply, and become vallies: those that are lightest, rise higher upon the earth's surface, and are called mountains.

Such was the face of nature before the deluge; the earth was then more fertile and populous than it is at present; the life of a man and animals was extended to ten times its present duration: and all these advantages arose from the *ſuperior heat* of the central globe, which ever since has been cooling.

As its *heat* was then in *full power,* the genial principle was also much greater than at present; vegetation and animal increase were carried on with more vigour; and *all nature ſeemed teeming with the ſeeds of life.*"

But I find I am now treading on slippery and enchanted ground. I shall hasten, therefore, to another explanation of this curious phœnomenon, less dependent on conjecture.—I fear I may be thought by some already to have gone too far into the bewitching and airy regions of fancy and conjecture.

SECT. XVIII.

THE SAME SUBJECT CONTINUED;

WITH A PARTICULAR ACCOUNT OF SOME ERUPTIONS OF MOUNT ÆTNA, AND VESUVIUS, AND THE EARTHQUAKE AT LISBON.

> . . . . Ah! whither now are fled
> Those dreams of greatness? Those unsolid hopes
> Of happiness? Those longings after fame?
> Those restless cares? Those busy, bustling days?
> Those gay-spent, festive nights? Those veering thoughts,
> Lost between good and ill, that shar'd thy life?
> *All now are vanish'd!*—VIRTUE sole survives,
> Immortal, never-failing friend of man,
> His guide to happiness on high. . . . . .
>
> Thomson.

We come now to another set of philosophers, who entertain the opinion, that the earth's *heat* arises from the *conflict of elements* contained within her bosom.

First, With regard to the heat found in deep caverns, which rises above that of the surrounding atmosphere, they conceive that this may proceed from other causes than an actual fire in the center of our globe.

For only call to your recollection the principles composing the earth, its copious stores of sulphureous, metallic, bituminous, and other inflammable matters, which have only to meet with oxygenated water, when a decomposition takes place, liberating a vast quantity of free *caloric.*

In Section XII. we mentioned the sentiments of Mayow respecting the cause of the Earth's heat, who was the first to attribute it to the conflict of its elements, and we shall soon have again occasion to notice his clear exposition of this sentiment, when we come to investigate the origin of hot-springs.

Lemery, who published a Practical Course of Chemistry the year after Mayow,[*] endeavours to account for subterraneous fires, from the following practical observations.

He mixed twenty-five pounds of powered *sulphur*, with an equal weight of *iron-filings*, and having kneaded the mixture together, by means of a little *water*, into the consistence of a paste, he put it into an iron pot, covered it with a cloth, and buried the whole a foot under ground.

In about eight or nine hours time, the earth swelled, grew warm, and cracked; hot sulphureous vapours were perceived, a flame which dilated the cracks was observed; the superincumbent earth was covered with a yellow and black powder; in short, a subterraneous fire, producing a volcano in miniature, was spontaneously lighted up from the reciprocal actions of sulphur, iron, and water.

The theory of this experiment is as follows. The *water* coming into contact with the *iron*, is decomposed. The *oxygen* of the *water* unites with the *iron*, and *hydrogen gas* (inflammable air) is given out, which dissolves a portion of *sulphur*, and becomes in consequence *sulphurated hydrogen gas*. This may be known by the fetid odour exhaled, as likewise by the flame emitted, which is more lively than that of sulphur, and less so than inflamed hydrogen air.

Mons. Beaumé, who observed this phenomenon, arising from an hundred pounds of iron-filings, and as much sulphur in powder, relates, that the flame produced rose to above a foot in height.[†]

That part of this experiment which relates to the production of flame, by the fermentation of iron-filings and sulphur when made into a paste, has been frequently repeated since the time of Lemery.

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[*] Mayow published in 1674. Vide note * page 62.

[†] How *this air* next comes to be inflamed, is probably as follows. The *oxygen* of the water over and above what saturates the iron, goes to form with the sulphur, sulphuric, or *vitriolic acid*, and we know that this acid mixed with water, raises it to a high temperature, and, under the present circumstances, sufficient to inflame the sulphurated hydrogen gas.

"*I myself*," says a dignified and learned prelate,* "have made it more than once, but I have nothing material to add to his account, except that the flame, when the experiment is made in the open air, is of very short duration; and that the whole mass, after the extinction of the flame, continues at intervals, for a longer or shorter time, according to its quantity, to throw out sparks; and that a ladlefull of the ignited mass, being dropped down from a considerable height, descends like a shower of red-hot ashes, much resembling the paintings of the eruptions of Mount Vesuvius."

It has been observed, that large quantities of such materials are not requisite to make the experiment succeed, provided there be a due proportion of water: half a pound of steel-filings, half a pound of flowers of brimstone, and fourteen ounces of water, will, when well mixed, acquire heat enough to occasion the mass to take fire.†

But that heat and fire, continues the learned Bishop, should be generated from the spontaneous actions of *minerals* upon each other, is a phenomenon not altogether singular of its kind.

In minerals, as well as vegetables, a definite quantity of moisture is alone requisite to enable them to commence that intestine motion of their parts, and those decompositions, which are necessary for the production of flame.

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* Dr. Watson, Bishop of Landaff, vide his *Chemical Essays*, in five volumes. In Vol. IV. we find the following very curious Preface: "Above two thousand copies of the former volumes of my Chemical Essays, have been sold in less than five years. I mention not this circumstance out of vanity, or as if I thought it contained any proof of their merit; but I produce it as a solid proof of the disposition of the public to become acquainted with chemical subjects, when they are treated in a popular way. This disposition has been long prevalent in foreign countries; it seems to be gaining ground in our own; and if I have endeavoured to contribute a little towards its establishment amongst us, I hope the utility of the design will plead my excuse with those who, in the severity of their judgments, may think that I have contributed to it more than, from the nature of my profession and situation, I ought to have done. When I was elected Professor of Divinity in 1771, I determined to abandon for ever the study of chemistry; and I did abandon it for several years: but the—*veteris vestigia flammæ*—still continued to delight me, and at length *seduced* me from my purpose. When I was made a Bishop in 1782, I again determined to quit my favourite pursuit: the Volume I now offer to the public is a *sad proof* of the imbecility of my resolution. I have on this day, however, offered a *sacrifice* to other people's notions, (certainly some Goths of the 18th century) I confess, rather than to my own opinion of *Episcopal Decorum*.—I have destroyed all my remaining chemical manuscripts.".. But it is yet to be hoped, that this Bishop will become a *sinner* again, and the public cannot fail to be benefited, as well as agreeably instructed; for as this most learned and elegant writer expresses himself elsewhere, "*The book of Nature and of Revelation, equally elevate our conceptions and incite our piety; they mutually illustrate each other; they have an* equal *claim to our regard, for they are both written by the finger of* One eternal, incomprehensible God, to whom be glory, for ever and ever, amen."

† Vide *Sage's Miner*. Vol. I. p. 42.

Iron and sulphur would remain mixed together for ages without inflaming, if they were kept perfectly free from water, being incapable of taking fire, whilst they continued in that state.

But though it is certain, from the experiments above, that mixtures of iron and sulphur, when moistened with a proper quantity of water, will spontaneously take fire; yet the origin of subterraneous fires cannot, with any great degree of probability, be referred to the same principle, unless it can be shewn, that nature has combined together in large quantities iron and sulphur, and distributed the composition through various internal parts of the earth.

Now that this is really the case, we can have no doubt. There is perhaps no mineral more commonly met with, than that which is composed of sulphur and iron. It has been found not only upon the surface of the earth, but at the greatest depths below it, to which mines have been hitherto driven; not only in England or Italy, Europe or Asia, but in all parts of the world.

In England it goes by the name of copperas-stone, from its yellow colour; but its scientific appellation is pyrites, from πυρ, fire, a denomination expressive enough of the property this mineral has of spontaneously taking fire, when laid in heaps, and subjected to moisture.

For although Lemery was the first person who, by artificial mixtures of water, sulphur, and iron, produced heat, yet that natural mixtures of these substances would spontaneously take fire, was known long before he made his experiments.

Thus, to omit what is said by Pliny and the ancients, we are told upon good authority,* that in the year 1664, one Wilson, at Ealing, in Yorkshire, had piled up in a barn many cart-loads of the pyrites, or brass-lumps, as they were called by the colliers, for making of vitriol, or some secret purposes of his own, when the roof happening to be bad, the pyrites were wetted by the rains, and in this state began to smoke, and presently took fire, and burnt like red-hot coals.

The same accident was observed, above an hundred years ago, at Puddle Wharf in London, where heaps of coal which contained much of this pyrites took fire.

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* Vide Power on the Microscope, who was contemporary with, and wrote a few years after, Hooke.

The same thing happened not long ago at Whitehaven, and in the neighbourhood of Halifax.

In the month of September, 1751, the Cliffs near Charmouth in Dorsetshire, took fire, in consequence of a heavy fall of rain after a hot and dry season, and they continued at intervals to emit flame for several years.

These cliffs consist of a dark-coloured bituminous loam, in which are imbedded large quantities of different kinds of the pyrites.

The same kind of flame has been frequently observed in the Cornish mines, and has often led to the discovery of the treasures in the earth; for wherever this has existed minerals, especially the pyrites, have universally been found.

There are some sorts of earth from which alum is made, which abound so much with pyrites that the proprietors of these works are forced to keep them constantly deluged with water, in order to keep them from firing.

But it seems useless to pursue this subject further; we have adduced proofs sufficient, that nature furnishes materials, which, under certain circumstances, may become the occasion of subterraneous fires.

The requisite circumstances are a proper quantity of the materials, and a proper proportion of water to moisten them.

A small quantity of the pyrites is sufficient to kindle a fire; water is almost every where found in such great plenty below the surface of the earth, that it constitutes one of the greatest impediments to our sinking pits to any great depth; and air, if it should be thought absolutely necessary to the spontaneous firing of the pyrites, may be conceived either to accompany the water in its dripping, or to descend into the innermost parts of the earth through fissures which are found upon its surface.

When a subterranean fire is once kindled, it may be supported for ages by other substances, as well as by those which first gave rise to it; thus if a quantity of the pyrites should take fire in a stratum of coal, or of shale, or any other substance strongly impregnated with bitumen, the fire might continue till the stratum was consumed.

There are some coaleries on fire now in Scotland, which were on fire in the time of Agricula (Pennant's Tour in Scot. p. 201). See an account of the coaleries on fire in Staffordshire, in Dr. Plott's Natural History of that country; and of the substances sublimed from the burning coal-pits at Newcastle in Philosoph. Trans. for 1676."

In coal-mines, besides the choak-damp, fixed air, the production of open as of slow combustion, we find the fire-damp, inflammable gas*, the secret product of decomposed water, or of vegetable matters.

This may be breathed with impunity in a certain state of dilution with common air; but if a candle should chance to light it, the whole is instantly fired, and the supporter of the flame and his companions meet with an untimely and dreadful end.†

But not minerals alone, but other substances also generate a great degree of heat.

The warmth of putrescent dunghills, of the fermenting juices of vegetables, and, more than all, the spontaneous firing of hay is well known to every one.

Vegetable decomposition is also, as we shall hereafter shew, when we come to the subject of agriculture, greatly accelerated by the power of lime.

This alkaline substance, when it appears in the form of a grey white stone, is called quicklime.

This is most frequently met with in places adjacent to volcanoes.

When exposed to the action of the air, lime swells, breaks, and falls into powder; it then increases greatly in bulk, and is called lime slaked in air.

These changes are more remarkable, and take place more rapidly, when the air is in a humid state.

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[*] This vapour is known in mines by the blue appearance of light, and is seen in flocculent balls floating above the pit. These assemble, and forming into one mass produce, when lighted, a terrific explosion. The miners hinder these natural balloons from assembling by driving them asunder with a fan elevated by a long stick, but when the quantity collected is great, the miners fall on their faces on the ground, and set fire to the lighter air above them. In certain mines replete with this air, as inflammable air is not kindled by a spark, and may be breathed with impunity, the miners continue to work, whilst a boy keeps turning a wheel which hits upon as many flints as there are opposing steels, and procures for them by this means a sufficiency of light.

[†] This happened to one of Lord Lonsdale's managers and some other people. As he was examining some parts of a mine, the boy was bid to hold the candle down and stoop, but, actuated by some sudden panic, he rose up, and an explosion taking place they were all burnt to death.

This dry slaking produces *heat*; and the dilatation is so considerable as to burst casks, or other wooden vessels in which lime may be contained.

These phænomena, says Fourcroy, are occasioned chiefly by the water contained in the atmosphere, and the force with which the lime tends to unite with it. For by heating lime which has been slaked with air in a retort, till it becomes red hot, water is obtained, and the lime returns to its original state.

Water acts very powerfully on quicklime. Pour a small quantity of that fluid on a quantity of lime, the water is instantly absorbed, and the mass of lime appears as dry as before; but it soon bursts and breaks into pieces.

The *heat* excited in it by this operation is so strong, as to produce a remarkable hissing noise: the water is reduced to vapour of a peculiar smell, which communicates a green colour to a paper tinged with syrup of violets. The lime soon falls down to a powder; and the heat, motion, and smoke gradually disappear. If the process be performed at night, in a place perfectly dark, a great many luminous points are observable all over the surface of the lime.

This remarkable phænomenon did not escape the active mind of Mayow, who, in Chapter XIV. of his elaborate work, treating on the *heat* from quicklime and the union of different salts, remarks, that this substance is a compound of two contrary principles, an acid and an alkali, and that the nitro-aerial-particles (oxygen) is so inherent in the acid, and in so dry a state, that they are inert, and as it were fixed; but when water pervades these two bodies, the laws of affinity then act, and these two opposite natures combine, and give out the heat which was before in a dormant state.

May we not rather attribute this process to the air in the interstices of of the water, and in part to a decomposition of the water; or does our present knowledge of the nature of lime give a sufficient solution of this question?

Seeing then that there are great chemical actions going on in the bowels of the earth, and observing the slow circulation of air, the heat consequently liberated from these natural processes becomes stagnant, and accounts readily for that uniformity observed at certain depths.

For, the earth possesses a wonderfully retentive power, only parting with its heat in the most gradual manner, which is proved by the following experiments of the illustrious Dr. HALES.

EXPERIMENT I.

This philosopher having observed that the air was at 88° of Farhenheit's thermometer, August 1, 1724, found that the earth at its surface had precisely the same heat; the thermometer being then plunged two inches deep into the ground, stood at 85°; another at sixteen inches, at 70°; and another at twenty-four inches, at 68°.

The two last preserved the same temperature day and night to the end of the month, and then only fell to 63°.

EXPERIMENT II.

On the 26th of October, a thermometer exposed to the air by the same philosopher stood at 35° 5; but one sunk two inches in the earth was found to rise to 43° 85, another sunk sixteen inches reached 48° 8, and one at twenty-four inches stood at 50°.

EXPERIMENT III.

He even found, that between the first and second of November, when the external air was at 27°, a thermometer at twenty-four inches depth stood at 43° 8.

EXPERIMENT IV.

When, in the coldest days of the winter 1724, the frost was so intense as to freeze the surface of stagnant water near an inch thick, Dr. Hales remarked, that his thermometer, which was exposed to the open air, was four degrees below the freezing point; and he found that placed two inches under ground it was four degrees above the freezing point; the third, fourth, and fifth thermometers were proportionably higher, as they were deeper in the ground, to the sixth thermometer, which being two feet under ground the spirit was as high as ten degrees above the freezing point.

This is shewn also by observing the progress of a thaw with snow on the ground, or an hoar-frost, which is dissolved on the surface of the ground, when it remains on the tiles, and on the tops of walls.

The preservation of gooseberries in bottles buried deep in the earth is a familiar example of this fact.

CONCLUSION FROM THESE EXPERIMENTS.

Hence Dr. Hales concludes, that the earth parts with its heat with difficulty to the air, and will retain its natural temperature, which is between 40° and 50°, at a very small depth beneath the surface, even when the air is below the freezing point, which is an admirable contrivance of Nature for the preservation of her offspring.

SECONDLY, with regard to the equal temperature of the *warm springs* found in many parts of the earth, the opinion that these arise from a subterranean fire did not escape the sagacious mind of the philosopher of the last century.

" Had the warmth of the Bath waters," says MAYOW, " proceeded, as some have supposed, from an actual subterranean fire, this in all probability had been extinguished by the waters themselves,* and this phænomenon had long since ceased."

" Hence it is more probable to suppose, that the superior temperature of these waters arises from a fermentation excited in the body of the earth itself."

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* In Ovid the *flood* is brought in, after the *battle of the giants,* which is hyperbolic of the eruption of burning mountains, which had devasted the earth, and threatened heaven itself, as a means to *quench these fires,* and reduce this torn and confounded face of things into some better form and order. And that Jupiter might be vindicated from the charge of cruelty towards the creatures of his hands, the men of those times (the iron age) are represented as extremely wicked, and the preservation of *Deucalion* and *Pyrrha* proves sufficiently his regard for mortals, and his wish to reward virtue.

Nunc mihi qua totum Nereus corcumsonat orbem
Perdendum est mortale genus.———
Cuncta prius tentanda, sed immedicabile vulnus
Ense recidendum est, ne pars sincera trahatur.

" Indeed, it must be allowed, that sometimes whole mountains are composed nearly wholly of vitriolated or aluminous marchasites."

" Also that the rains sink through the spongy substance of the earth, and finding a proper channel, constitute springs, containing within their pores the *nitro-aerial particles*,* as essential to the production of fire, which the air-pump demonstrates."

" For if rain or other water be put into a glass, and the air extracted from this by suction, immediately are seen numerous bubbles of air rushing from the body of the water."

" We may now remark, that if these *salino-sulphureous* mountains be humected with *water*, an effervescence will take place, and *heat* be induced."

" For if marchasites, or any salino-sulphureous glebe, mixed with either vitriol, or any similar salt, be exposed abroad to an humid atmosphere, or the rains of heaven, these in a short time will in a remarkable way ferment. Thus also, if any *salino-sulphureous mineral*, recently dug up, be moistened with *rain*, this in a short space of time will ferment and give out *heat*."

" In confirmation of this doctrine," continues Mayow, " the high hills by which the wells of Bath are surrounded, abound with *marchasites*, and these waters shew an impregnation of the nature of an *acid*, for if any alkali be mixed with these waters, a precipitation soon is excited, and they become turbid, and then white."

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* The *nitro-aerial particles*, or *oxygen*, may arise also in part from *the decomposition of the mineral acids*. If we mix two parts of *spirits of wine* with one of *fresh fuming spirits of nitre* (the oxygenated nitric acid) the mixture will remain cold for near ten minutes, and it will after that time begin to acquire some degree of heat, till at length it will boil with great violence for a considerable length of time.

In like manner, by mixing together equal bulks of *strong spirit of vitriol* (the sulphuric acid) with *water*, we can raise from these bodies, previously cold, a degree of heat nearly equal to what boiling water exhibits.

If the *fuming acid of nitre* (the nitric acid) be mixed with *oil of turpentine*, let it be in the depth of winter, and when these two fluids are severally colder than ice, yet you will see them, to the utter astonishment of those not much versed in chemical phænomena, instantaneously catch fire, and kindle a powerful flame. A pint of each being employed will raise a column of fire and smoke more than twenty feet in height.

In the Philosophical Transactions for 1699, we have a table expressing at one view, the effect which the *nitrous acid* has upon a variety of other oils, as well as that of turpentine, and we find there enumerated twelve sorts of oils, which, when mixed with the *acid of nitre* (the nitrous acid) effervesced and exploded with a flame.

In addition to the information contained in this table, we are indebted to the French chemists for a variety of interesting memoirs on the inflammation of oils, both by the simple nitrous acid, and by that acid, when mixed with the vitriolic acid.

Musschenbroeck has related above 200 experiments, illustrating the alteration of the temperature arising from the mixture of different substances with water, spirits of wine, and the mineral and vegetable acids.

From this cause these unite badly with soap, since the acid of these waters conflicts with the alkali of the soap, and so blunts its virtues, that the sulphureous and oily part of the soap, now liberated from the fixed salt, cannot mix with the water, but swims on its surface."

THIRDLY, respecting the cause of *earthquakes*, as proceeding from some inward commotion of the central parts of the earth, the cessation of many volcanos, which may be said to be burnt out;* and the less frequency of these occurrences in our times, is a strong argument against this sentiment.

A better explanation of these wonderful *phænomena* seems to me given by the learned and ingenious Dr. Hook, who, after stating his objections to the opinion entertained by some, that the centre of the earth was liquid fire,[*]

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* In Spallanzani's Travels in the Two Sicilies there are numerous examples of this fact. Chap. xvi. Observations on Lipari. 'I ascended,' says this philosophic traveller, 'to the summit of Monto San Angelo, situated to the north of the city of Lipari, this being the highest mountain of the Island.

The top, far from having a conical figure, such as is that of Stromboli, and in a certain manner Vulcano, was composed of groups of broken mountains, confusedly heaped together, which gave it a most irregular appearance.

It is evident that the *volcanic fires have raged in many places,* and that, from their too great proximity to each other, they have not been able to form those distinct cones which are so observable in Vesuvius and on Ætna.

But the matter ejected by the superior volcanos, pouring upon those which issued from the lower, have produced in every part confusion and disorder to be observed there.

From the summit of Ætna we may discover a multitude of subjacent craters, well characterised; but from that of San Angelo I could not perceive one. There are, indeed, many openings and hollows to be seen, which *once* were fiery mouths; but none of these have at present the figure of an inverted funnel, being filled up, or destroyed by time.

That fires existed in the time of Aristotle is certain. Και το εν τη Λιπαρα δε πυρ φανερον και φλογωδες, ου μεν ἥμερας, αλλα νυκτος μονον και εσθαι λεγεται. Since which time there is no mention of any fires appearing in that island.'

Speaking of Felicuda and Alicuda, two islands to the westward of Lepari, Chapter xvii, he says, 'both shewed vestiges of their *primitive crater*, that is, of that which gave birth to each respective island.

The volcanic materials were numerous, yet were there no signs of any activity in these islands to be discovered, except a warm spring in Felicuda, which issues from a rock on the northern side of these islands.'

I shall here collect the observations which have been left us by the ancients relative to these two islands, as these are extremely brief, and few.

Aristotle, speaking of Phenicura, as it was then styled, says, 'it received its name from its abounding in palms,' φοινιξ, φοινικος, being the Greek appellation of that tree.'

Ericusa, as it was then called, was derived, according to Strabo, from heath, 'erica,' which was abundant there.

But neither of the above writers, or any other of the ancient authors, mention any fires as existing in these two islands, although they relate that Lipari, Stromboli, and Vulcano, threw out flames, as these, it is more than probable, were *wholly extinguished* in those days.'

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[*] The Greeks entertained the notion that *hell,* or the place for the manes of departed people, was in the centre of the earth, and that there were certain passages leading thither, as the river Lethe, and the Acherusian cave. These were long roads, hence their custom of putting pieces of money into the mouths of the dead to pay their journey. At Hermione the way was shorter, and hence the omission there of the custom of putting money into the mouths of the departed.

Milton gives us a fine poetic description of the rivers which descend into, and mingle with the flames of hell—

——————— They bend
Four ways their flying march along the banks
Of four infernal rivers that disgorge
Into the *burning lake* their baleful stream:
Abhorred Styx, the flood of deadly hate;
Sad Aceron, of sorrow black and deep;
Cocytus, named from lamentation loud,
Heard on the rueful stream; fierce Phlegethon,
Whose waves of torrent fire inflame with rage;
Far off from those a slow and silent stream,
Lethe, the river of oblivion, rolls, &c.

The Greeks fancied the *umbra,* or *ghost,* hovered near the place where the death happened, whilst the *spirit, spiritus,* went to heaven. This idea is expressed in the following lines attributed to Ovid.

Bis duo sunt homini: Manes, Caro, Spiritus, Umbra,
  Quatuor ista loci bis duo suscipient.
Terra tegit *Carnem,* tumulum circumvolat *Umbra,*
  Orcus habet *Manes, Spiritus* astra petit.

Thus Homer:

——— The fates suppress'd his lab'ring breast,
And his eyes stiffen at the hand of death;
To the realms above the *spirit* wings its way,
The manly *body* stops, a load of clay,
And plaintive glides along the dreary coast,
The naked—wand'ring—melancholy—*ghost.*

The Jews seem to have entertained the same notion of *hell* as the Greeks, and hence our Saviour, adapting his discourse to their conceptions, gives the parable of Dives and Lazarus.—The word *infernal* comes from *inferus, below*; and on the stage these are always represented with torches in their hands, and involved in flames.—But there is nothing in natural or revealed religion to authorise such a conception. God is every where represented in Scripture in his true character, as the God of "Love" and "Mercy." "He wills, that all mankind should be saved." 2 Tim. ii. 4. "In my Father's house there are many mansions," says our Lord. S. John xiv. 2. Is it not then more than probable that those innumerable stars we see above us are replete with *inhabitants,* and that we pass from one star, or world, to another star, or world, either *approaching* towards, or *receding* from that Being (the plenitude of happiness, the cause of all things, whom we in this world behold as through a glass darkly; i.e. faintly conceiving the idea by the contemplation of the works of creation and redemption), according to our spent lives, and that every *punishment* inflicted on man is founded in *justice* tempered with *mercy?* Can there be any conception more noble than this? An infinity of stars, and each stored with an infinite number of differently created beings enjoying different degrees of happiness! If there are 10,000 insects, and 300 animals, reckoning the kinds in this world of sorrow, and delight, how vast the conception of millions of worlds and myriads of different beings, and each distinct and perfect as a whole, yet making but a link in the chain of created beings! Even the sight of the splendour of the heavenly bodies is the grandest spectacle in nature.

When the moon, refulgent lamp of night,
O'er heav'n's clear azure spreads her sacred light,
When not a breath disturbs the deep serene,
And not a cloud o'ercasts the solemn scene——
Around her throne the vivid planets roll,
And stars unnumber'd gild the glowing pole.
Then shine the vales, the rocks in prospect rise,
And floods of glory burst from all the skies.

HOMER.

That we have *pre-existed* is supported both by revelation as well as reason, for when the Jews brought the boy born blind to CHRIST, asking " for whose sin did this misfortune happen, whether as an affliction to his parents, or for his own sin"—" Neither," says our blessed LORD, " was it for his own sins, (mark he was *born* blind) nor for those of his parents; but (in this particular instance) that the power of GOD might be made manifest." And " Christ touched the eyes of the boy, and he that was blind immediately saw." So if we consult reason, we cannot fail to observe some children exhibiting the most perverse disposition, even in their very cradle, and others again as good; and there is no life, however esteemed here as prosperous, but has its afflictions, which shews us to be in the state of punishment, or purification. The doctrine, says the celebrated Ramsay, of the creation of a new soul at every birth, and this pure innocent spirit to be incarcerated in a weak body, subject to innumerable accidents, and diseases, and so actuating the spirit, as to render it afterwards liable to the torment of an eternal fire, and the reason of GOD acting so, because of the sin of one man, who lived 4000 years ago, and with whom we have no more connexion than with Nero, or Caligula, is contrary to every notion we should entertain of GOD, and of his attributes. He is truly " the God of Love," and the whole relation of Moses is therefore figurative. The fall of Adam is only the *type* of the true condition of all of us here. He was surrounded by objects of creation the most agreeable. A consort was added to complete his paradisiacal felicity. In this blessed state he was subject to commandment, and the story of the apple is only *allegorical* of the ease there was in obedience, " My yoke is easy, and my burthen is light." But possessing *free-will*, for so it pleased God, man abused his nature, and was driven out of paradise; and whether he passed from one star to another star, or the abode *was altered*, is immaterial to our argument. The poet may be allowed to manage it as he pleases.—How fine is his account of this matter.

——— He scrupled not to eat
Against his better knowledge, not deceiv'd,
But fondly overcome with female charm,——
Earth trembled from her entrails as again
In pangs, and Nature gave a second groan;
Sky lour'd, and muttering thunder, some sad drops
Wept, at the completing of the mortal sin
Original.—Then to diverse angels GOD gave charge
As sorted best with present things. The sun
Had first his precept so to move, so shine
As might affect the earth with cold and heat
Scarce tolerable, and from the north to call
Decrepit winter, from the south to bring
Solstitial summer's heat. To the blank moon
Her office they prescrib'd, to th' other five
Their planetary motions and aspects
In sextile, square, and trine, and opposite
Of noxious efficacy, and when to join
In synod unbenign; and taught the fix'd
Their influence malignant when to shower,
Which of them rising with the sun, or falling,

Should prove tempestuous: to the winds they set
Their corners, when with bluster to confound
Sea, air, and shore; the thunder when to roll
With terror through the dark aerial hall.
Some say He bid his angels turn ascanse
The poles of earth twice ten degrees and more
From the sun's axle. They with labour push'd
Oblique the centric globe; some say the sun
Was bid turn reins from th' equinoxial road
Like distant breadth to Taurus with the seven
Atlantic Sisters, and the Spartan Twins
Up to the Tropic Crab; thence down amain
By Leo and the Virgin, and the Scales,
As deep as Capricorn, to bring in change
Of seasons to each clime; *else had the spring*
Perpetual smil'd on earth with vernant flowers,
Equal in days and nights, except to those
Beyond the polar circles; to them day
Had unbenighted shone, while the low sun,
To recompense his distance, in their sight
Had rounded still th' horizon, and not known
Or east or west, which had forbid the snow
From cold Estotiland, and south as far
Beneath Magellan. At that tasted fruit
The sun, as from Thyestean banquet, turn'd
His course intended; else how had the world
Inhabited, though sinless, more than now,
Avoided pinching cold and scorching heat?
These changes in the Heav'ns, though slow, produc'd
Like change on sea and land, sideral blast,
Vapour, and mist, and exhalation hot,
Corrupt and pestilent: now from the north
Of Norumbega, and the Samoed shore,
Bursting their brazen dungeon, arm'd with ice,
And snow, and hail, and stormy gust, and flaw,
Boreas, and Cæcias, and Argestes loud,
And Thrascias rend the woods, and seas upturn;
With adverse blast upturns them from the south
Notus and Afer; black with thund'rous clouds,
From Serraliona; thwart of these as fierce
Forth rush the Levant and the Ponent winds,
Eurus and Zephyr, with their lateral noise,
Sirocco and Lebecchio. Thus began
Outrage from lifeless things; but Discord first,
Daughter of Sin, among the irrational,
Death introduc'd through fierce antipathy:
Beast now with beast 'gan war, and fowl with fowl,
And fish with fish; to graze the herb all leaving,
Devour'd each other; nor stood much in awe
Of man, but fled him, or with count'nance grim
Glar'd on him passing. These were from without
The growing miseries which Adam saw
Already in part, though hid in gloomiest shade,

To sorrow abandoned, but worse felt within,
And in a troubled sea of passion tost,
Thus to disburden sought with sad complaint.
“ O miserable of happy! is this the end
Of this new glorious world, and me so late
The glory of that glory, who now become
Accurs’d of blessed, hide me from the face
Of God, whom to behold was then my height
Of happiness!———
O unexpected stroke, worse than of death!
Must I thus leave thee, Paradise? thus leave
Thee, native soil, these happy walks and shades,
Fit haunt of gods? where I had hope to spend,
Quiet, though sad, the respite of that day
That must be mortal to us both? O *flowers,*
That never will in other climate grow,
My early visitation, and my last
At even, which I bred up with tender hand
From the first opening bud, and gave ye names,
Who now shall rear ye to the sun, or rank
Your tribes, and water from th’ ambrosial fount?
Thee lastly, nuptial bow’r, by me adorn’d
With what to sight or smell was sweet, from thee
How shall I part, and whither wander down
Into a *lower world,* to this obscure
And wild? how shall I breathe in other air
Less pure, accustom’d to immortal fruits?
O miserable of Mankind, to what fall
Degraded, to what wretched state reserv’d!
Better end here unborn. Why is life given
To be thus wrested from us? rather why
Obtruded on us thus? who, if we knew
What we receive, would either not accept
Life offer’d, or soon beg to lay it down,
Glad to be so dismiss’d in peace. Can thus
Th’ image of God, in man created once
So goodly and erect, though faulty since,
To such unsightly sufferings be debas’d
Under inhuman pains? Why should not man,
Retaining still divine similitude
In part, from such deformities be free,
And for his Maker’s image sake exempt?”
“Their Maker’s image,” answer’d Michael, “then
Forsook them, when themselves they vilify’d
To serve ungovern’d appetite, and took
His image whom they serv’d, a brutish vice,
Inductive mainly to the sin of Eve.
Therefore so abject is their punishment,
Disfiguring not God’s likeness, but their own,
Or of his likeness, by themselves defac’d,
While they pervert pure Nature’s healthful rules
To loathsome sickness, worthily, since they
God’s image did not reverence in themselves.

“I yield it just,” said Adam, and submit.
But is there yet no other way, besides
These painful passages, how we may come
To death, and mix with our connatural dust?”
“There is,” said Michael, “if thou well observe
The rule of not too much, by temp'rance taught,
In what thou eat'st and drink'st, seeking from thence
Due nourishment, not gluttonous delight,
Till many years over thy head return:
So may'st thou live, till like fruit thou drop
Into thy mother's lap, or be with ease
Gather'd, not harshly pluck'd, for death mature:
This is old age; but *then* thou must outlive
Thy youth, thy strength, thy beauty, which will change
To wither'd, weak, and gray; thy senses then
Obtuse, all taste of pleasure must forego
To what thou hast; and for the air of youth,
Hopeful and cheerful, in thy blood shall reign
A melancholy damp of cold and dry
To weigh thy spirits down, and last consume
The balm of life.” To whom our Ancestor:
“Henceforth I fly not death, nor would prolong
Life much, bent rather how I may be quit
Fairest and easiest of this cumbrous charge,
Which I must keep till my appointed day
Of rendering up, and patiently attend
My dissolution.” Michael reply'd:
“Nor love thy life, nor hate: but what thou liv'st
Live well; how long or short permit to Heav'n.”

Michael then shews, that God tempers his *judgments* with *mercy,* and points out to Adam the promise of *redemption* of mankind through Christ. For as there is a chain of exalted beings, cherubs, cherubims, and seraphims, so at the summit is *Christ,* so exalted in nature as to be equal to God, and being a direct emanation from that inconceivable spirit, the nearest approximation to the Godhead, therefore one part of the holy Trinity. With the utmost condescension this emanation, whose act it was to produce our globe amidst applauding angels, is embodied in a human form, reveals the will of God, and satisfies infinite justice, by an atonement for the sins of the whole world, and thus overcomes death. “Oh grave, where is now thy victory.” How comforting the words, “I am the resurrection and the life!” In the divine volume we are also informed of administering angels. We are objects of their special concern. They first receive our departed spirits, when we shake off the mortal coil. How friendly the office to lessen our astonishment at the opening splendour of a *new world!* Vide Petitpierre on Divine Goodness, proving the *Universal Redemption* as a *Scriptural Doctrine.*

That there were no *infernal regions* and *eternity of punishments,* was also conjectured by the wisest among the ancients. Lucretius, Lib. III. 991.

———— The dismal tales that poets tell
Are verified on earth, and not in hell.
No Tityus, torn by vultures, lies in hell,
Nor could the lobes of his small liver swell
To that prodigious mass, for their eternal meal:
But he's the Tityus, who, by love oppress'd,
Or tyrant passion preying on his breast,
And ever anxious thoughts, is robb'd of rest.
The Sisiphus is he, whom noise and strife
Seduce from all the soft retreats of life,

To vex the government, disturb the laws;
Drunk with the fumes of ignorant applause,
He courts the idle crowd to make him great,
And sweats, and toils in vain, to mount the sov'reign seat;
For still to aim at pow'r, and still to fail,
Ever to strive, and never to prevail,
What is it but, in Reason's true account,
To heave the stone against the rising mount?

The idea of subterranean fires, and the spirits of the damned inhabiting them, arose from that superstition, which *personified* all *extraordinary natural powers.* Hence the fable of the giants, from γη, the earth, and γεινομαι, to spring from, born of the earth: these are represented as in that part of Tartarus, or Hell, where the depth in the earth is twice as great as the height extends to the throne of Heaven.

——— Tum Tartarus ipse
Bis patet in præceps tantum, tenditque sub umbras,
Quantus ad ætherium Cœli suspectus Olympum,
Hic genus antiquum terræ, Titania pubes
Fulmine dejecti, fundo volvuntur in imo.

VIRG.

Hence the description of Æneas's terror when he was shewn,

Et centumgemitus Briareus, et bellua Lernæ.
Horrendum stridens, flammisque armata chimæra.

All which is descriptive of burning mountains, and this is more fully verified by Jupiter's putting over these giants the mountains of Peleon, and Ossa, in order to keep them under.

The fable of the rape of Proserpine, by Pluto, fully verifies this supposition. She is described as the offspring of Ceres, and is plainly delineated, as a city situate where the Lake Pergusa is at present, and the country around is filled with cascades, woods, and flowers, just such as Proserpine is said to have been innocently sporting in, when Pluto on a sudden seized upon her, and carried her to his dreary realms. In this metamorphosis, or fable, the rebellious giant Typhæus is represented as covered by the Island Tinacria, Sicily; and such was his violent struggle to get liberated, that Dis or Pluto is fearful lest the vault of earth covering his own residence should be broken up,

——— Et Rex pavet ipse silentum.

This brought the God of Terrors up, who falls in love with the beauty of Proserpine, that is, becomes enamoured of the fair town of Pegusa, and it is swallowed up, and the remainder of the story is taken up with a description of the devastation occasioned by this earthquake, by representing the pursuit of Ceres after her daughter, over the earth, and her return to Sicily, shewing how Sicily was again rendered fruitful and abundant in corn.

Milton's rebellion of the angels is taken from the Gigantomachia of the ancients.

Forthwith (behold the excellence, the pow'r,
Which God hath in his mighty angels plac'd)
Their arms away they threw, and to the hills
(For earth hath this variety from heav'n
Of pleasure situate in hill and dale)
Light as the lightning glimpse they ran, they flew;
From their foundations loos'ning to and fro,
They pluck'd the seated hills, with all their load,
Rocks, waters, woods, and by the shaggy tops
Up-lifting bore them in their hands. Amaze,
And fright, and terror seiz'd the rebel host,
When coming towards them so dread they saw
The bottom of the mountains upward turn'd;

Till on those cursed engines triple-row
They saw them whelm'd, and all their confidence
Under the weight of mountains buried deep;
Themselves invaded next, and on their heads
Main promontories flung, which in the air
Came shadowing, and oppress'd whole legions arm'd;
Their armour help'd their harm, crush'd in and bruis'd
Into their substance pent, which wrought them pain
Implacable, and many a dolorous groan,
Long struggling underneath, ere they could wind
Out of such pris'n, though spirits of purest light,
Purest at first, now *gross* by sinning grown.
The rest in imitation to like arms
Betook them, and the neighb'ring hills uptore;
So hills amid the air encounter'd hills
Hurl'd to and fro with jaculation dire,
That under ground they fought in dismal shade;
Infernal noise; war seem'd a civil game
To this uproar: horrid confusion heap'd
Upon confusion rose. And now all heav'n
Had gone to wreck, with ruin overspread,
Had not th' Almighty FATHER, where HE sits
Shrin'd in his sanctuary of heav'n secure,
Consulting on the sum of things, foreseen
This tumult, and permitted all, advis'd;
That his great purpose HE might so fulfil,
To honour his anointed SON aveng'd
Upon his enemies.——
HE on his impious foes right onward drove,
Gloomy as night; under his burning wheels
The stedfast empyrean shook throughout,
All but the throne itself of GOD. Full soon
Among them HE arriv'd, in his right hand
Grasping ten thousand thunders, which he sent
Before him, such as in their souls infix'd
Plagues: they astonish'd, all resistance lost,
All courage; down their idle weapons dropt:
O'er shields, and helms, and helmed heads he rode
Of thrones and mighty seraphim prostrate,
That wish'd the mountains now might be again
Thrown on them, as a shelter from his ire.
Nor less on either side tempestuous fell
His arrows, from the fourfold-visag'd Four
Distinct with eyes, and from the living wheels
Distinct alike with multitude of eyes;
One spirit in them rul'd, and every eye
Glar'd lightning, and shot forth pernicious fire
Among the accurs'd, that wither'd all their strength,
And of their wonted vigour left them drain'd,
Exhausted, spiritless, afflicted, fall'n.
Yet half his strength he put not forth, but check'd
His thunder in mid volley; for he meant
Not to destroy, but root them out of heav'n;
The overthrown he rais'd, and as a herd
Of goats or tim'rous flock together throng'd,

or, as other learned men have supposed, an immense cavern of water,*

Drove them before him thunder-struck, pursu'd
With terrors and with furies to the bounds
And crystal wall of heav'n; which op'ning wide,
Roll'd inward, and a spacious gap disclos'd
Into the wasteful deep: the monstrous sight
Struck them with horror backward, but far worse
Urg'd them behind; headlong themselves they threw
Down from the verge of heav'n; and dreadful wrath
Burnt after them to the bottomless pit.
Hell heard th' unsufferable noise, Hell saw
Heav'n ruining from Heav'n, and would have fled
Affrighted; but strict fate had cast too deep
Her dark foundations, and too fast had bound.
Nine days they fell; confounded Chaos roar'd,
And felt tenfold confusion in their fall
Through his wild anarchy, so huge a rout
Incumber'd him with ruin: Hell at last
Yawning receiv'd them whole, and on them clos'd;
Hell, their fit habitation, fraught with fire
Unquenchable, the house of woe and pain.
Disburden'd Heav'n rejoic'd, and soon repair'd
Her mural breach, returning whence it roll'd.

* Milton represents the centre as a chaos,

Before their eyes in sudden view appear
The secrets of the centre, a deep and dark
Illimitable ocean, without bound,
Without dimension, whose length, breadth, and height,
And time, and place, are lost; where eldest Night
And Chaos, ancestors of Nature, hold
Eternal anarchy, amidst the noise
Of endless wars, and by confusion stand.

But Descartes, and others, have supposed this centre to be a hollow filled with water. Some have in this way interpreted the words of Moses, who, speaking of the deluge, mentions 'that God broke up the fountains of the great deep.' In the history of every kingdom of the world, there are found traditions of this extensive or universal *deluge*, and Whiston has supposed it to have arisen from a comet, which was conceived to be the sun in those distant days, which was supposed to have wandered from its course, and hence the story of Deucalion and Pyrrha, and of Phaeton. This fiery meteor, or comet, proceeding from pole to pole, melted the ice which occupies or caps the two hemispheres, and thus produced this universal deluge. We should, however, first remark, that the effusion of but part of the ices of the Cordeliers, in Peru, is sufficient to produce an annual overflow of the Amazons, of the Oroonoko, and of several other great rivers of the new world, and to inundate a considerable part of the Brazils, of Guiana, and the terra firma of America; and that in like manner the melting of part of the snows on the mountains of the Moon in Africa, occasions every year the inundations of Senegal, the overflowing of the Nile, and that similar effects are annually produced in a considerable part of southern Asia, in the kingdoms of Bengal, Siam, Pegou, Cochin-China, and in the districts watered by the Tigris, Euphrates, and many other rivers of Asia, which have their sources in chains of mountains perpetually covered with ice, namely, Taurus and Imaus. Who then can doubt, but that the total fusion of the ices of the poles, would be sufficient to inundate the whole globe, without having recourse to the hollow of the earth, being replete with waters? Only paint to yourself this catastrophe, if the mind can stretch to the conception, which gives us so sublime an idea of the power of the Almighty, equally great as the Creator, and as the dissolver of his works; and you would behold torrents of thawed ice and snow, issuing from all the flood-gates of the poles, from the Straits of the Sea of Anadir, from the Gulphs of Kamschatka, from the Baltic Sea, from the Straits of Stagat, from the unknown sluices of Spitzbergen, and Greenland, from Hudson's Bay, and from parts which can have no name, and these issuing in two opposite directions, tearing up all before them, then were the elephants of Africa tossed among the firs of Siberia, whose bones are found to this day, and the shells of the sea-shore carried to the tops of mountains, vestiges of which are every where to be seen. In this confusion of elements every thing was mingled, cities, palaces, majestic pyramids, triumphal arches; and the vapour arising from the comet, acting on these new waters, caused a perfect mist, and the rain of forty days and forty nights; and it was one hundred and fifty days before these waters returned to their proper channel and were again frozen at the poles. In employing a comet the Almighty acted by second causes, but He chose to make a *miraculous* preservation of one family, and one genus of each kind of animal and plant; and who shall put limits to his power, and say, that this was impossible? or can we suppose, that this deluge, of which every history has some record, was *very extensive*, but *not universal*, and that by means of *navigation* these desolated parts became again to be inhabited, and resume its wonted beauty, and accept of the *figurative*, rather than the *literal interpretation of Scripture*, in what relates to an *historical representation?* 'The fountains of the great deep were broken up,' according to this interpretation, would relate to the fissures and cracks produced on the earth by the piercing heat of the fiery comet.—

Tum facta est Libye raptis humoribus æstu
Arida, tum Nymphæ passis, fontesque lacusque
Diflevere comis—v. 237.
Dissilit omne solum penetratque in Tartara rimis
Lumen et infernum terret cum conjuge regem.
Et mare contrahitur, siccæque est campus arenæ,
Quod modo pontus erat; quosque altum texerat æquor
Existunt montes, et sparsas Cycladas augent.—Ovid, v. 260.

That the deluge arose from the overflowings of the sea may be drawn from the book of Job, (chap. xxxviii. ver. 8.) which was written by Moses as a moral tale, or parable, to inspire the children of Israel with patience and confidence in God.—Under his heavy affliction he asks, "Who appointed gates to the sea, and *shut it up again*, after it had *inundated the earth*, rushing, as from the womb of its mother?"—This is mentioned in enumeration of the other wonderful works of God, illustrative of his *judgments* and *mercy*.—Such contemplations to some may appear gloomy, but, on the contrary, they serve to elevate the mind, and raise it from low and vulgar conceptions, and to make us look forward with fond hope to another earth, where there are no *mines* ready to explode, under our very footsteps, or *waters* to burst their bounds, and overwhelm us in an instant. Can there be any thoughts higher or more consoling than these we are recording? That successive generations of men have arisen to possess the earth. By turns they have passed away, and gone into regions unknown. Us He hath raised up, to occupy their room. We too shall shortly disappear. But human existence never perishes. Life only changes its form, and is renewed. Creation is ever filling, but never full. As a shepherd leads his flock from one pasture to another, so the great Creator leads forth the souls which he has made, into new and prepared abodes of life. They go from this earth to a new earth, and new heavens; and still they remove, only from one province of the divine dominion to another. Amidst all these changes of nature, the great Ruler himself remains, "*without variableness or shadow of turning*." To him, these successive revolutions of being are but "*as yesterday*." From his eternal throne, he beholds worlds rising and passing away; measures out, to the creatures who inhabit them, powers and faculties suited to their state; and distributes among them rewards and punishments, proportioned to their actions.——What an astonishing view do such meditations afford of the kingdom of God; infinite in its extent; everlasting in its duration; exhibiting, in every period, the reign of perfect righteousness and wisdom! "*Who by searching can find out* God? *who can find out* the Almighty *to perfection? Great and marvellous are all thy works, Lord God* Almighty! *Just and true are all thy ways, thou* King of saints!"

relates the following opinion, arising from the consideration of certain chemical phænomena.

" Being," says this philosopher, " but a mile distant from the powder-mills of Hackney, when they blew up, the great noise and shock it occasioned brought to my recollection what had lately happened at the Isle of MODUNDA, which it seems is all an uninhabited rock, and was split by an earthquake, and a part of it tumbled down, and sunk into the sea, upon which occasion there was heard first a prodigious *noiſe* like the roaring of *cannon**, attended with a cloud of smoak."

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* The famous Bishop BERKLEY gives us an account of an eruption of mount VESUVIUS, in which he paints these "pleasing dreadful scenes" with all the ability of a great master. I reached, says he, with much difficulty in the year 1717, the middle of April, the top of mount VESUVIUS, in which I saw a vast aperture full of smoke, which hindered me from seeing its depth and figure. I heard within that horrid gulf certain extraordinary sounds, which seemed to proceed from the bowels of the mountain, a sort of murmuring, sighing, dashing sound, and between whiles a noise like that of thunder or cannon, with a clattering like that of tiles falling from the tops of houses into the streets. Sometimes, as the wind changed, the smoke grew thinner, discovering a very ruddy flame, and the circumference of the crater streaked with red and several shades of yellow. After an hour's stay, the smoke being moved by the wind, gave us short and partial prospects of the great hollow; in the flat bottom of which I could discern two furnaces almost contiguous; that on the left seeming about three yards over, glowing with ruddy flame, and throwing up red-hot stones, with an *hideous noise*, which, as they fell back, caused the clattering already taken notice of. May 8, in the morning, I ascended the top of Vesuvius a second time, and found a different face of things. The smoke ascending upright, gave a full prospect of the crater, which, as I could judge, was about a mile in circumference, and an hundred yards deep. A conical mount had been formed since my last visit, in the middle of the bottom, which I could see was made by the stones, thrown up and fallen back again into the crater. In this new hill remained the two furnaces already mentioned. The one was seen to throw up every three or four minutes, with a *dreadful sound*, a vast number of red-hot stones, at least three hundred feet higher than my head, as I stood upon the brink; but as there was no wind, they fell perpendicularly back from whence they had been discharged. The other was filled with red-hot liquid matter, like that in the furnace of a glass-house; raging and working like the waves of the sea, with a short abrupt noise. This matter would sometimes boil over, and run down the side of the hill, appearing at first red-hot, but changing colour as it hardened and cooled. Had the wind driven in our faces, we had been in no small danger of stifling by the sulphureous smoke, or being killed by the masses of melted minerals, that were shot from the bottom. But as the wind was favourable, I had an opportunity of surveying this amazing scene for above an hour and a half together. On the fifth of June, after an *horrid noise*, the mountain was seen at Naples to work over; and about three days after, its thunders were renewed so, that not only the windows in the city, but all the houses shook. From that time it continued to overflow, and sometimes at night were seen columns of fire shooting upward from its summit. On the tenth, when all was thought to be over, the mountain again renewed its terrors, roaring and raging most violently. One cannot form a juster idea of the *noise*, in the most violent fits of it, than by imagining a mixed sound, made up of *the raging of a tempest, the murmur of a troubled sea, and the roaring of thunder and artillery*, confused all together. Though we heard this at the distance of twelve miles, yet it was very terrible. I therefore resolved to approach nearer to the mountain; and accordingly, three or four of us got into a boat, and were set ashore at a little town, situated at the foot of the mountain. From thence we rode about four or five miles, before we came to the torrent of fire that was descending from the side

of the volcano; and here the *roaring* grew exceeding loud and terrible as we approached. I observed a mixture of colours in the cloud, above the crater, green, yellow, red, blue. There was likewise a ruddy dismal light in the air, over that tract where the burning river flowed. These circumstances, set off and augmented by the horror of the night, made a scene the most uncommon and astonishing I ever saw; which still increased as we approached the burning river. Imagine a vast torrent of liquid fire, rolling from the top, down the side of the mountain, and with irresistible fury bearing down and consuming vines, olives, and houses; and divided into different channels, according to the inequalities of the mountain. The largest stream seemed half a mile broad at least, and five miles long. I walked so far before my companions up the mountain, along the side of the river of fire, that I was obliged to retire in great haste, the sulphureous steam having surprised me, and almost taken away my breath. During our return, which was about three o'clock in the morning, the roaring of the mountain was heard all the way, while we observed it throwing up huge spouts of fire and burning stones, which falling, resembled the stars in a rocket. Sometimes I observed two or three distinct columns of flame, and sometimes one only that was large enough to fill the whole crater. These burning columns, and fiery stones, seemed to be shot a thousand feet perpendicular above the summit of the volcano! and in this manner the mountain continued raging for six or eight days after. On the eighteenth of the same month the whole appearance ended, and the mountain remained perfectly quiet, without any visible smoke or flame."

But the latest and clearest account of this most formidable phænomenon we have from the late Envoy Sir William Hamilton. He begins with remarking, "That the frequent slight eruptions of lava for some years past had issued from near the summit, and ran in small channels in different directions down the flanks of the mountain, and from running in covered channels, had often an appearance as if they came immediately out of the sides of Vesuvius, but such lavas had not sufficient force to reach the cultivated parts at the foot of the mountain. In the year 1779, the whole quantity of the lava in fusion having been at once thrown up with violence out of the crater of Vesuvius, and a great part of it falling, and cooling on its cone, added much to the solidity of the walls of this huge natural chimney, and had not of late years allowed of a sufficient discharge of lava to calm that fermentation, which by the subterraneous noises heard at times, and by the explosions of scoriæ and ashes, was known to exist within the bowels of the volcano; so that the eruptions of late years, before this last, were simply from the lava having boiled over the crater, the sides being sufficiently strong to confine it, and oblige it to rise and overflow. The mountain had been remarkably quiet for seven months before the late eruption, nor did the usual smoke issue from its crater, but at times it emitted small clouds of smoke that floated in the air in the shape of little trees.

SIGNS.

It was remarked by the Father Antonio di Petrizzi, a capuchin friar (who printed an account of the late eruption) from his convent close to the unfortunate town of Torre del Greco, that for some days preceding this eruption a thick vapour was seen to surround the mountain, about a quarter of a mile beneath its crater, as it was remarked by him, and others at the same time, that both the sun and the moon had often an unusual reddish cast.

The water of the great fountain at Torre del Greco began to decrease some days before the eruption, so that the wheels of a corn-mill, worked by that water, moved very slowly; it was necessary in all the other wells of the town and its neighbourhood to lengthen the ropes daily, in order to reach at the water; and some of the wells became quite dry. Although most of the inhabitants were sensible of this phenomenon, not one of them seems to have suspected the true cause of it. Eight days also before the eruption, a man and two boys, being in a vineyard above Torre del Greco (and precisely on the spot where one of the new mouths opened, whence the principal current of lava that destroyed the town issued) were much alarmed by a sudden puff of smoke which issued from the earth close to them, and was attended with a slight explosion.

Had this circumstance, with that of the subterraneous noises heard at Resina for two days before the eruption (with the additional one of the decrease of water in the wells) been communicated at the time, it would have required no great foresight to have been certain that an eruption of the volcano was near at hand, and that its force was directed particularly towards that part of the mountain.

ERUPTION.

Judging from these appearances, I warned my family not to be suddenly alarmed, as I had reason to expect an earthquake; and curiosity led me to visit the mountain. It was about noon on the 20th of October, 1769, when on a sudden I heard an uncommon *bellowing* within its cavity, and about a quarter of a mile from the place where I stood, the mountain was split in twain, and with much noise from this chasm a fountain of liquid fire shot up many feet high, and like a torrent rolled on directly towards where I stood. The earth shook, at the same time that a volley of pumice stones fell thick upon us; in an instant, clouds of black smoke and ashes caused almost a total darkness; the *explosions* from the top of the mountain *were much louder than any thunder I ever heard, and the smell of the sulphur was very offensive.* My guide, alarmed, took to his heels; and I must confess, that I was not at my ease. I followed close, and we ran near three miles without stopping; as the earth continued to shake under our feet, I was apprehensive of the opening of a fresh mouth, which might have cut off our retreat. I also feared that the *violent explosions* would detach some of the rocks off the mountain of Somma, under which we were obliged to pass; besides, the pumice-stones, falling upon us like hail, were of such a size as to cause a disagreeable sensation upon the part where they fell. After having taken breath, as the earth still trembled greatly, I thought it most prudent to leave the mountain, and return to my villa; where I found my family in a great alarm, at the continual and violent explosions of the volcano, which shook our house to its very foundation, the doors and windows swinging upon their hinges.

The noise and smell of sulphur increasing, we removed from our villa to Naples; and I thought proper, as I passed by Portici, to inform the court of what I had seen; and humbly offered it as my opinion, that his Sicilian Majesty should leave the neighbourhood of the threatening mountain. However, the court did not leave Portici till about twelve of the clock. I observed, in my way to Naples, which was in less than two hours after I had left the mountain, that the lava had actually covered three miles of the very road through which we had retreated. It is astonishing that it should have run so fast; as I have since seen, that the river of lava, in the Atrio di Cavello, was sixty and seventy feet deep, and in some places near two miles broad. When his Sicilian Majesty quitted Portici, the *noise* was greatly increased; and the concussion of the air from the *explosions* was so violent, that, in the king's palace, doors and windows were forced open; and even one door there, which was locked, was nevertheless burst open. At Naples, the same night, many windows and doors flew open; in my house, which is not on the side of the town next Vesuvius, I tried the experiment of unbolting my windows, when they flew wide open upon every explosion of the mountain. Besides these explosions, which were very frequent, there was a continued *subterraneous* and *violent rumbling noise,* which lasted this night about five hours. I have imagined, that this extraordinary noise might be owing to the lava in the bowels of the mountain having met with a deposition of rain water; and that the conflict between the fire and the water may, in some measure, account for so extraordinary a crackling and hissing noise. Padre Torre, who has wrote so much and so well upon the subject of Mount Vesuvius, is also of my opinion. And indeed it is natural to imagine, that there may be rain-water lodged in many of the caverns of the mountain; as, in the great eruption of Mount Vesuvius in 1631, it is well attested, that several towns, among which Portici and Torre del Greco, were destroyed, by a torrent of *boiling water* having burst out of the mountain with the lava, by which thousands of lives were lost. About four years ago, Mount Etna in Sicily threw up hot water also, during an eruption.

The confusion at Naples this night cannot be described; his Sicilian Majesty's hasty retreat from Portici added to the alarm; all the churches were opened and filled; the streets were thronged with processions of saints: but I shall avoid entering upon a description of the various ceremonies that were performed in this capital, to quell the fury of the turbulent mountain.

Tuesday the 20th, it was impossible to judge of the situation of Vesuvius, on account of the smoke and ashes, which covered it entirely, and spread over Naples also, the sun appearing as through a thick London fog, or a smoked glass; small ashes fell all this day at Naples. The lavas on both sides of the mountain ran violently; but there was little or no noise till about nine o'clock at night, when the same *uncommon rumbling* began again, accompanied with explosions as before.

Wednesday twenty-first, was more quiet than the preceding days, though the lavas ran briskly, Portici was once in some danger, had not the lava taken a different course when it was only a mile and a half from it; towards night, the lava slackened.

Thursday twenty-second, about ten of the clock in the morning, the same *thundering noise* began again, but with more violence than the preceding days; the oldest men declared, they had never heard the like; and, indeed, it was very alarming: we were in expectation every moment of some dire calamity. The ashes, or rather small cinders, showered down so fast, that the people in the streets were obliged to use umbrellas, or flap their hats; these ashes being very offensive to the eyes. The tops of the houses, and the balconies, were covered above an inch thick with these cinders. Ships at sea, twenty leagues from Naples, were also covered with them, to the great astonishment of the sailors.

It is worthy of observation, that at this time there were no clouds in the air, yet these ashes were *wet*, and accompanied with a *salt taste*. Hence Dr. EMANUEL SCOTTI, Professor of Philosophy in the University of Naples, supposes, in his printed account of this eruption, that this *water* is the product of an explosion of *inflammable* and *oxygen airs*.

ÆTNA.

This mountain is divided into three distinct regions, called La Regione Culta: the Fertile Region; La Regione Sylvosa, the Woody Region; and La Regione Deserta, the Barren Region.

The three are as different, both in climate and productions, as the three zones of the earth: and perhaps with equal propriety might have been stiled the torrid, the temperate, and the frigid zone. The first region surrounds the foot of the mountain, and constitutes the most fertile country in the world on all sides of it, to the extent of about fourteen or fifteen miles, where the woody region begins. It is composed almost entirely of lava, which, after a number of ages, is at last converted into the most fertile of all soils.

Every eruption generally forms a new mountain. As the great Crater of Ætna itself is raised to such an enormous height above the lower regions of the mountain, it is not possible that the internal fire raging for vent, even round the base, and no doubt vastly below it, should be carried to the height of twelve or thirteen thousand feet to the summit of Ætna. It has therefore generally happened, that after shaking the mountain and its neighbourhood for some time, it at last bursts open its side. At first it only sends forth a thick smoke and showers of ashes, that lay waste the adjacent country: these are soon followed by red-hot stones, and rocks of a great size, thrown to an immense height in the air. The fall of these stones, together with the quantity of ashes discharged at the same time, at last form one of these spherical and conical mountains. Sometimes this process is finished in the course of a few days: sometimes it lasts for months, which was the case in the eruption of 1669. In that case the mountains formed are of a great size; some of them are not less than seven or eight miles round, and upwards of one thousand feet in perpendicular height: others are not more than two or three miles round, and three or four hundred feet high.

After the new mountain is formed, the lava generally bursts out from its lower side; and bearing away every thing before it, is for the most part terminated by the sea. This is the common progress of an eruption; however, it sometimes happens, though rarely, that the lava bursts at once from the side of the mountain, without all these attending circumstances; and this is commonly the case with the eruption of Vesuvius, where the elevation being much smaller, the melted matter is generally carried up into the crater of the mountain, which then discharges showers of stones and ashes from the mouth of the volcano, without forming any new mountain, but only adding considerably to the height of the old one; till at last the lava, rising near the summit, bursts the side of the crater, and the eruption is declared. This has been the case with two eruptions lately; but Ætna is upon a much larger scale, and one crater is not enough to give vent to such oceans of liquid fire.

A Sicilian gentleman saw in an eruption of that mountain, large rocks of fire discharged to the height of some thousand feet, with a noise more terrible than that of thunder. He measured from the time of their greatest elevation, till they reached the ground, and found they took twenty-one seconds to descend, which (the spaces being as the squares of the times) amounted to upwards of seven thousand feet!

After contemplating these objects for some time, says another traveller, we set off, and soon after arrived at the foot of the great crater of Ætna. This is of an exact conical figure, and rises equally on all sides. It is composed solely of ashes, and other burnt materials, discharged from the mouth of the volcano, which is in its centre. This conical mountain is of a very large size: its circumference cannot be less than ten miles. Here we took a second rest, as the greatest part of our fatigue still remained. The mercury had fallen to 20 4½. We found this mountain excessively steep; and although it had appeared black, yet it was likewise covered with snow, but the surface (luckily for us) was spread over with a pretty thick layer of ashes, thrown from the crater. Had it not been for this, we should have been able to get to the top.

The circumference of this zone or great circle on Ætna is not less than seventy or eighty miles. It is every where covered by the vineyards, orchards, and corn-fields that compose the Regione Culta, or the Fertile Region. The last zone is much broader than the others, and extends on all sides to the foot of the mountain. Its whole circumference is 183 miles.

The present crater of this immense volcano is a circle of about three miles and a half in circumference. It goes shelving down on each side, and forms a regular hollow, like a vast amphitheatre. From many places of this space issue volumes of sulphureous smoke, which being much heavier than the circumambient air, instead of rising in it, as smoke generally does, immediately on its getting out of the crater, rolls down the side of the mountain like a torrent, till coming to that part of the atmosphere of the same specific gravity with itself, it shoots off horizontally; and forms a large tract in the air, according to the direction of the wind; which happily for us, carried it exactly to the side opposite to that where we were placed. The crater is so hot that it is very dangerous, if not impossible, to go down into it: besides the smoke is very incommodious, and in many places the surface is so soft, there have been instances of people sinking down into it and paying for their temerity with their lives. Near the centre of the crater is the great mouth of the volcano, that tremendous gulph so celebrated in all ages. We beheld it with awe, and with horror, and were not surprised that it had been considered by the vulgar, as Hecla is at present, as the place of the damned, and its noises as their groans. When we reflect on the immensity of its depth, the vast cells and caverns whence so many lavas have issued; the boiling of the matter, the shaking of the mountain, the explosion of flaming rocks, we must allow that the liveliest imagination hardly ever formed an idea of hell more dreadful.

It is a curious consideration that this mountain should re-unite every beauty and every horror; and in short, all the most opposite and dissimilar objects in nature. Here you observe a gulph, that formerly threw out torrents of fire now covered with the most luxuriant vegetation; and from an object of horror becomes one of delight. Here you gather the most delicious fruits, rising from what was lately a black and barren rock. Here the ground is covered with every flower; and we wander over those beauties, and contemplate this wilderness of sweets without considering that hell and all its terrors, is immediately under our feet, and that a few yards separate us from lakes of liquid fire and brimstone.

But our astonishment still increases, on casting our eyes on the higher regions of the mountain. There we behold in perpetual union, the two elements that are at perpetual war; an immense gulph of fire, for ever existing in the midst of snows, which it has not power to melt; and immense fields of snow and ice for ever surrounding this gulph of fire, which they have not power to extinguish.

An eruption of Mount Ætna, in 1669, was preceded for eighteen days, with a dark, thick sky, thunder, lightning, and frequent tremblings of the earth. The place of eruption was twenty miles from the old mouth: the matter of it was a stream of melted minerals, boiling up and gushing out, as water does at the head of a great river. Having run thus for more than a stone's cast, the extremities began to crust, and turn into porous stones, resembling huge cakes of sea coal, full of a fierce fire. These came rolling over one another, and where any thing opposed, filled up the space and rolled over. But they bore down any common building, and burnt up all that was combustible. This inundation went on about a furlong a day, for nineteen or twenty days. It overwhelmed fourteen towns and villages. The noise of the eruption was heard sixty miles.

On Sunday, March 9, 1755, about noon, Mount Ætna began to cast from its mouth a great quantity of flame and smoke, with a most horrible noise. At four o'clock the air became quite dark and covered with black clouds. At six a shower of stones, each weighing about three ounces, began to fall over all the city of Mascali and its territories. This shower lasted till a quarter past seven; and was succeeded all night by a shower of black sand. On Monday morning at eight, there sprang from the bottom of the mountain a river of scalding-hot water, which in half a quarter of an hour, overflowed all the rugged land that is near the foot of the hill, and suddenly going off, left the whole a large plain of sand. The stones and sand which remain wherever this water reached, differ in nothing from the stones and sand of the sea, and have even the same saltness. After the water was gone there sprang from the same opening a small stream of fire, which continued for four and twenty hours. On Tuesday, about a mile below this opening, there arose another stream of fire, which being in breadth about four hundred feet, overflowed all the adjacent country.

On the 3d of December, 1754, a stream of liquid fire began to run down the side of Mount Vesuvius, from an opening on the east-side. But it soon ceased running from this orifice, and burst out from a much larger one, about two hundred yards below it. Afterward it burst out from a third orifice, and having ran some space with great fury, the surface then began to cool and incrust, as it ran over gently-declining ground, till it came within about ten yards of the top of a steep declivity. Here the fire collected, as in a reservoir, to supply a cascade, which rushed down from thence in a channel of more than twenty feet wide, and about two hundred yards in length, with a fall of at least fifty feet. After this the stream was less rapid, but grew wider, and spread several miles from its source. It now presented a very different scene from what it afforded before. The cascade (says an eye-witness) looks like melted gold, and tears off large bodies of old lava (so they term the incrustation) which float down the stream, till the intenseness of the heat lifts them from the bottom. But in the lower country, it divides into smaller streams, running with less rapidity: and yet with such violence, that it drives the strongest stone fences before it, and lighting the trees, like torches, affords a most extraordinary, though dismal spectacle.

Not to detain the reader too long on these phænomena, I shall only give him the fine description of another eye-witness, Kircher, respecting an eruption of Mount Ætna.

Proceeding onward, says this traveller, I could not fail to cast my eyes on this justly famed mountain, and I saw it cast forth large volumes of smoke, which entirely covered the whole island. This together with the dreadful noise, filled me with apprehension. The sea itself began to wear a very unusual appearance, covered all over with bubbles. My surprise was increased by the calmness of the weather. I therefore warned my companions, that an earthquake was approaching, and making for the shore with all possible speed, we landed at Tropæ. But we had scarcely arrived at the Jesuit's College in that city, when our ears were stunned with a *horrid sound resembling that of an infinite number of chariots driven fiercely forward, the wheels rattling, and the thongs cracking.* Soon after, the whole tract upon which we stood, seemed to vibrate, as if we were in the scale of a balance wavering. This soon grew more violent, and being no longer able to keep my legs, I was thrown prostrate upon the ground. In the mean time, the universal ruin round me, redoubled my amazement. The crash of falling houses, the tottering of towers, and the groans of the dying, all contributed to raise my terror. On every side of me, I saw nothing but a scene of ruin, danger threatening wherever I could fly. I recommended myself to God as my last refuge. At that hour, O how vain was every sublunary happiness! Wealth, honour, empire, wisdom, all mere useless sounds, and as empty as the bubbles on the deep. Just standing on the threshold of eternity, nothing but GOD was my pleasure, and the nearer I approached, I only loved him the more. After some time, however, I resolved to venture for safety, and running as fast as I could, reached the shore. I did not search long, till I found the boat in which I had landed and my companions also. Our meeting was all silence, with gloomy dread of impending terrors. The place on which we stood, now began to shake most dreadfully, so that being unable to stand, my companions and I caught hold of the shrubs near us, and supported ourselves in that manner. After some time this shock ceasing, we stood up in order to go to Euphæmia, that lay within sight. But when I turned my eyes towards the city, I could see only a dark cloud resting upon the place. This the more surprised us, as the weather was so serene. We waited till the cloud was partly away, then looking for the city, it was totally sunk. Nothing but a putrid lake was seen where it stood. We looked about for some one that could tell us the sad catastrophe, but could see none. All was become a melancholy solitude, a scene of hideous desolation. Such was the fate of the city of Euphæmia. And as we continued our melancholy course along the shore, the whole coast for the space of two hundred miles presented nothing but the remains of cities.

EARTHQUAKE AT LISBON.

Earthquakes have so great affinity with the eruptions of volcanos, that, according to our plan, we will proceed to the consideration of one of the most memorable, and in the recollection of most of us.

We should notice that, previous to an eruption of Vesuvius, the earth always trembles, and subterraneous explosions are heard. On the first of November, 1755, the æra so fatal to Lisbon, the island of Madeira was violently shaken by an earthquake, accompanied with subterraneous explosions. So thoroughly convinced, indeed, are the inhabitants of volcanic countries of the connection between earthquakes and volcanoes, that when a great eruption takes place from a volcano, they congratulate themselves on having escaped an earthquake.

Earthquakes, as well as volcanic eruptions, are always preceded by a violent agitation of the sea. Previous to the breaking out of Vesuvius, the sea retires from the adjacent shores till the mountain is burst open, and then it returns with such impetuosity, as to overflow its usual boundary. About an hour after the first shocks, which alarmed the city of Lisbon in 1755, the sea was observed to come rushing towards the city like a torrent, though against both wind and tide; it rose forty feet higher than was ever known, and as suddenly subsided. A ship, fifty leagues off at sea, received so violent a shock as greatly to injure the deck, &c. The same effect was observed at Cadiz, and at a variety of ports throughout the Mediterranean, and, indeed, more or less, all over Europe.

In 1691 and 1698 vast torrents of boiling water flowed from the crater of Vesuvius, previous to the eruption of fire: and what was, perhaps, still more remarkable, many species of sea-shells, in a calcined state, were found on the brink of the crater, and also in the channel formed by the flood. The same thing happened at Ætna, in 1755, when a dreadful torrent of boiling water flowed from the crater at the time of an eruption of fire. Sir William Hamilton observes, that the sea-shells emitted along with the water clearly indicate a communication with the sea. All warm springs probably receive their heat from the action of pyrites, near which the water passes.

The following exact account of the great Lisbon earthquake is extracted from a volume of letters, published by the Rev. Mr. Davy.

There was never a finer morning seen than the first of November (1755); the sun shone out in its full lustre; the whole face of the sky was perfectly serene and clear, and not the least signal or warning of that approaching event, which has made this once flourishing, opulent, and populous city, a scene of the utmost horror and desolation, except only such as served to alarm, but scarcely left a moment's time to fly from the general destruction.

It was on the morning of this fatal day, between the hours of nine and ten, that I was sat down in my apartment, just finishing a letter, when the papers and table I was writing on began to tremble with a gentle motion, which rather surprised me, as I could not perceive a breath of wind stirring; whilst I was reflecting with myself what this could be owing to, but without having the least apprehension of the real cause, the whole house began to shake from the very foundation, which at first I imputed to the rattling of several coaches in the main street, which usually passed that way, at this time, from Belem to the palace: but on hearkening more attentively, I was soon undeceived, as I found it was owing to a strange frightful kind of noise underground, resembling the hollow distant rumbling of thunder; all this passed in less than a minute, and I must confess I now began to be alarmed, as it naturally occurred to me, that this noise might possibly be the forerunner of an earthquake, as I remembered that which had happened about six or seven years ago, in the island of Madeira, commenced in the same manner, though it did little or no damage.

Upon this I threw down my pen, and started upon my feet, remaining a moment in suspense, whether I should stay in the apartment, or run into the street, as the danger in both places seemed equal; and still flattering myself that this tremor might produce no other effects than such inconsiderable ones as had been felt at Madeira; but in a moment I was roused from my dream, being instantly stunned with a most horrid crash, as if every edifice in the city had tumbled down at once. The house I was in shook with such violence, that the upper stories immediately fell, and though my apartment (which was the first floor) did not then share the same fate, yet every thing was thrown out of its place in such a manner, that it was with no small difficulty I kept my feet, and expected nothing less than to be soon crushed to death, as the walls continued rocking to and fro in the frightfullest manner, opening in several places, large stones falling down on every side from the cracks, and the ends of most of the rafters starting out from the roof. To add to this terrifying scene, the sky in a moment became so gloomy, that I could now distinguish no particular object; it was an Egyptian darkness indeed, such as might be felt; owing, no doubt, to the prodigious clouds of dust and lime, raised from so violent a concussion, and as some reported, to sulphureous exhalations, but this I cannot affirm; however, it is certain I found myself almost choked for near ten minutes.

As soon as the gloom began to disperse, and the violence of the shock seemed pretty much abated, the first object I perceived in the room was a woman sitting on the floor, with an infant in her arms, all covered with dust, pale and trembling; I asked her how she got hither: but her consternation was so great, that she could give me no account of her escape; I suppose, that when the tremor first began, she ran out of her own house, and finding herself in such imminent danger from the falling of stones, retired into the door of mine, which was almost contiguous to her's, for shelter, and when the shock increased, which filled the door with dust and rubbish, ran up stairs in to my apartment, which was then open: be it as it might, this was no time for curiosity. I remember the poor creature asked me, in the utmost agony, if I did not think that the world was at an end; at the same time she complained of being choked, and begged for God's sake I would procure her a little drink; upon this I went to a closet where I kept a large jar with water (which you know is sometimes a pretty scarce commodity in Lisbon), but finding it broken in pieces, I told her she must not now think of quenching her thirst, but saving her life, as the house was just falling on our heads, and if a second shock came, would certainly bury us both; I bade her take hold of my arm, and that I would endeavour to bring her into some place of security.

I shall always look upon it as a particular providence, that I happened on this occasion to be undressed; for had I dressed myself, as I proposed, when I got out of bed, in order to breakfast with a friend, I should, in all probability, have run into the street at the beginning of the shock, as the rest of the people in the house did, and consequently have had my brains dashed out, as every one of them had; however, the imminent danger I was in did not hinder me from considering that my present dress, only a gown and slippers, would render my getting over the ruins almost impracticable: I had, therefore, still presence of mind enough left to put on a pair of shoes and a coat, the first that came in my way, which was every thing I saved, and in this dress I hurried down stairs, the woman with me, holding by my arm, and made directly to that end of the street which opens to the Tagus, but finding the passage this way entirely blocked up with the fallen houses to the height of their second stories, I turned back to the other end which led into the main street (the common thoroughfare to the palace), and having helped the woman over a vast heap of ruins, with no small hazard to my own life, just as we were going into the street, as there was one part I could not well climb over without the assistance of my hands, as well as my feet, I desired her to let go her hold, which she did, remaining two or three feet behind me, at which time there fell a vast stone from a tottering wall, and crushed both her and the child in pieces: so dismal a spectacle at any other time would have affected me in the highest degree, but the dread I was in of sharing the same fate myself, and the many instances of the same kind which presented themselves all around, were too shocking to make me dwell a moment on this single subject.

I had now a long narrow street to pass, with the houses on each side four or five stories high, all very old, the greater part already thrown down, or continually falling, and threatening the passengers with inevitable death at every step, numbers of whom lay killed before me, or, what I thought far more deplorable, so bruised and wounded, that they could not stir to help themselves. For my own part, as destruction appeared to me unavoidable, I only wished I might be made an end of at once, and not have my limbs broken, in which case I could expect nothing else but to be left upon the spot, lingering in misery, like these poor unhappy wretches, without receiving the least succour from any person.

As self-preservation, however, is the first law of nature, these sad thoughts did not so far prevail as to make me totally despair. I proceeded on as fast as I conveniently could, though with the utmost caution; and having at length got clear of this horrid passage, I found myself safe and unhurt in the large open space before St. Paul's church, which had been thrown down a few minutes before, and buried a great part of the congregation, that was generally pretty numerous, this being reckoned one of the most populous parishes in Lisbon. Here I stood some time, considering what I should do, and not thinking myself safe in this situation, I came to the resolution of climbing over the ruins of the west end of the church, in order to get to the river side, that I might be removed, as far as possible, from the tottering houses, in case of a second shock.

This, with some difficulty, I accomplished, and here I found a prodigious concourse of people, of both sexes, and of all ranks and conditions, among whom I observed some of the principal canons of the patriarchal church, in their purple robes and rochets, as these all go in the habit of bishops; several priests who had run from the altars in their sacerdotal vestments in the midst of their celebrating mass; ladies half dressed, and some without shoes; all these, whom their mutual dangers had here assembled to a place of safety, were on their knees at prayers, with the terrors of death in their countenances, every one striking his breast, and crying out incessantly, *Miserecordia meu Dios*.

In the midst of our devotions, the second great shock came on, little less violent than the first, and completed the ruin of those buildings which had been already much shattered. The consternation now became so universal, that the shrieks and cries of *Miserecordia* could be distinctly heard from the top of St. Catherine's hill, at a considerable distance off, whither a vast number of people had likewise retreated; at the same time we could hear the fall of the parish church there, whereby many persons were killed on the spot, and others mortally wounded. You may judge of the force of this shock, when I inform you, it was so violent, that I could scarce keep on my knees, but it was attended with some circumstances still more dreadful than the former.—On a sudden I heard a general outcry, 'The sea is coming in, we shall be all lost.'—Upon this, turning my eyes towards the river, which in that place is near four miles broad, I could perceive it heaving and swelling in a most unaccountable manner, as no wind was stirring; in an instant there appeared, at some small distance, a large body of water, rising like a mountain; it came on foaming and roaring, and rushed towards the shore with such impetuosity, that we all immediately ran for our lives, as fast as possible; many were actually swept away, and the rest above their waist in water at a good distance from the banks. For my own part, I had the narrowest escape, and should certainly have been lost, had I not grasped a large beam that lay on the ground, till the water returned to its channel, which it did almost at the same instant, with equal rapidity. As there now appeared at least as much danger from the sea as the land, and I scarce knew whither to retire from shelter, I took a sudden resolution of returning back with my clothes all dropping, to the area of St. Paul's: here I stood some time, and observed the ships tumbling and tossing about, as in a violent storm; some had broken their cables, and were carried to the other side of the Tagus; others were whirled round with incredible swiftness; several large boats were turned keel upwards; and all this without any wind, which seemed the more astonishing. It was at the time of which I am now speaking, that the fine new quay, built entirely of rough marble, at an immense expence, was entirely swallowed up, with all the people on it, who had fled thither for safety, and had reason to think themselves out of danger in such a place; at the same time a great number of boats and small vessels, anchored near it (all likewise full of people, who had retired thither for the same purpose) were all swallowed up, as in a whirlpool, and never more appeared.

This last dreadful incident I did not see with my own eyes, as it passed three or four stones throws from the spot where I then was, but I had the account as here given from several masters of ships, who were anchored within two or three hundred yards of the quay, and saw the whole catastrophe. One of them in particular informed me, that when the second shock came on, he could perceive the *whole* city waving backwards and forwards, like the sea when the wind first begins to rise; that the agitation of the earth was so great even under the river, that it threw up his large anchor from the mooring, which swam, as he termed it, on the surface of the water; that immediately upon this extraordinary concussion, the river rose at once near twenty feet, and in a moment subsided; at which instant he saw the quay, with the whole concourse of people upon it, sink down, and at the same time every one of the boats and vessels that were near it were drawn into the cavity, which he supposes instantly closed upon them, inasmuch as not the least sign of a wreck was ever seen afterwards. This account you may give full credit to, for as to the loss of the vessels, it is confirmed by every body; and with regard to the quay, I went myself a few days after, to convince myself of the truth, and could not find even the ruins of a place, where I had taken so many agreeable walks, as this was the common rendezvous of the factory in the cool of the evening. I found it all deep water, and in some parts scarcely to be fathomed.

This is the only place I could learn which was swallowed up in or about Lisbon, though I saw many large cracks and fissures in different parts, and an odd phenomenon I must not omit, which was communicated to me by a friend who has a house and wine-cellars on the other side of the river, viz. that the dwelling-house being first terribly shaken, which made all the family run out, there presently fell down a vast high rock near it, that upon this the river rose and subsided in the manner already mentioned, and immediately a great number of small fissures appeared in several contiguous pieces of ground, whence there spouted like a *jet d' eau* a large quantity of fine white sand, to a prodigious height.

I had not been long in the area of St. Paul's, when I felt the third shock, which though somewhat less violent than the two former, the sea rushed in again, and retired with the same rapidity, and I remained up to my knees in water, though I had gotten upon a small eminence at some distance from the river, with the ruins of several intervening houses to break its force. At this time I took notice the waters retired so impetuously, that some vessels were left quite dry, which rode in seven fathom water: the river thus continued alternately rushing on and retiring several times together, in such sort, that it was justly dreaded Lisbon would now meet the same fate which a few years ago had befallen the city of Lima.

Perhaps you may think the present doleful subject here concluded; but, alas! the horrors of the first of November are sufficient to fill a volume. As soon as it grew dark, another scene presented itself little less shocking than those already described—the whole city appeared in a blaze, which was so bright that I could easily see to read by it. It may be said, without exaggeration, it was on fire at least in an hundred different places at once, and thus continued burning for six days together, without intermission, or the least attempt being made to stop its progress.

I could never learn, that this terrible fire was owing to any subterraneous eruption, as some reported, but to three causes, which all concurring at the same time, will naturally account for the prodigious havoc it made; the first of November being All Saints Day, a high festival among the Portuguese, every altar in every church and chapel (some of which have more than twenty) was illuminated with a number of wax tapers and lamps, as customary; these setting fire to the curtains and timber work that fell with the shock, the conflagration soon spread to the neighbouring houses, and being there joined with the fires in the kitchen chimnies, increased to such a degree, that it might easily have destroyed the whole city, though no other cause had occurred, especially as it met with no interruption.

The fire, by some means or other, may be said to have destroyed the whole city, at least every thing that was grand and valuable in it; and the damage on this occasion is not to be estimated.

During this calamitous scene, it is impossible to conceive the horrors and wretchedness of the unhappy inhabitants. The jaws of death were opened to swallow them up; ruin had seized all their possessions, and those dear connexions to which they might have looked for consolation in their sorrows, were for ever buried in the merciless abyss. All was ruin and desolation. Every countenance indicated the extremity of affliction and despair; and the whole country formed a wide scene of undescribable horror.

The whole number of persons that perished, including those who were burnt, or afterwards crushed to death whilst digging in the ruins, is supposed, on the lowest calculation, to amount to more than sixty thousand; and though the damage in other respects cannot be computed, yet you may form some idea of it, when I assure you, that this extensive and opulent city is now nothing but a vast heap of ruins, that the rich and poor are at present upon a level, some thousands of families which but the day before had been easy in their circumstances, being now scattered about in the fields, wanting every conveniency of life, and finding none able to relieve them.

As this is one of the most exact accounts of an earthquake, so we are favoured by Sir William Hamilton with a full description of the eruption of Vesuvius, which happened in 1794.

Sir William Hamilton begins his narrative with remarking, that the frequent slight eruptions of lava for some years past had issued from near the summit, and ran in small channels in different directions down the flanks of the mountain, and from running in covered channels, had often an appearance as if they came immediately out of the sides of Vesuvius, but such lavas had not sufficient force to reach the cultivated parts at the foot of the mountain. In the year 1779, the whole quantity of lava in fusion having been at once thrown up with violence out of the crater of Vesuvius, and a great part of it falling, and cooling on its cone, added much to the solidity of the walls of this huge natural chimney, and had not of late years allowed of a sufficient discharge of lava to calm that fermentation, which by the subterraneous noises heard at times, and by the explosions of scoriæ and ashes, was known to exist within the bowels of the volcano; so that the eruptions of late years, before this last, were simply from the lava having boiled over the crater, the sides being sufficiently strong to confine it, and oblige it to rise and overflow. The mountain had been remarkably quiet for seven months before the late eruption, nor did the usual smoke issue from its crater, but at times it emitted small clouds of smoke that floated in the air in the shape of little trees. It was remarked by the Father Antonio di Petrizzi, a capuchin friar (who printed an account of the late eruption) from his convent close to the unfortunate town of Torre del Greco, that for some days preceding this eruption a thick vapour was seen to surround the mountain, about a quarter of a mile beneath its crater, as it was remarked by him, and others at the same time, that both the sun and the moon had often an unusual reddish cast.

The water of the great fountain of Torre del Greco began to decrease some days before the eruption, so that the wheels of a corn-mill, worked by the water, moved very slowly; it was necessary in all the other wells of the town and its neighbourhood to lengthen the ropes daily, in order to reach at the water; and some of the wells became quite dry. Although most of the inhabitants were sensible of this phenomenon, not one of them seems to have suspected the true cause of it. Eight days also before the eruption, a man and two boys, being in a vineyard above Torre del Greco (and precisely on the spot where one of the new mouths opened, whence the principal current of lava that destroyed the town issued) were much alarmed by a sudden puff of smoke which issued from the earth close to them, and was attended with a slight explosion.

Had this circumstance, with that of the subterraneous noises heard at Resina for two days before the eruption (with the additional one of the decrease of water in the wells) been communicated at the time, it would have required no great foresight to have been certain that an eruption of the volcano was near at hand, and that its force was directed particularly towards that part of the mountain.

On the 12th of June 1794, in the morning, there was a violent fall of rain, and soon after the inhabitants of Resina, situate directly over the ancient town of Herculaneum, were sensible of a rumbling subterraneous noise, which was not heard at Naples.

From the month of January to the month of May, the atmosphere was generally calm, and there was continual dry weather. In the month of May there was a little rain, but the weather was unusually sultry. For some days preceding the eruption, the Duke della Torre, a learned and ingenious nobleman, who published two letters upon the subject of the eruption, observed by his electrometers, that the atmosphere was charged in excess with the electric fluid, and continued so for several days during the eruption.

About eleven o'clock on the night of the 12th of June, the inhabitants of Naples were all sensible of a violent shock of an earthquake; the undulatory motion was evidently from east to west, and appeared to have lasted near half a minute. The sky, which had been quite clear, was soon after covered with black clouds. The inhabitants of the towns and villages, which are very numerous at the foot of Vesuvius, felt this earthquake still more sensibly, and say, that the shock at first was from the bottom upwards, after which followed the undulation from east to west. This earthquake extended all over the Campagna Felice; and the royal palace at Caserta, which is fifteen miles from Naples, and one of the most magnificent and solid buildings in Europe (the walls being eighteen feet thick) was shook in such a manner as to cause great alarm, and all the chamber bells rang. It was likewise much felt at Beneventum, about thirty miles from Naples; and at Ariano in Puglia, which is at a much greater distance; both these towns, indeed, have been often afflicted with earthquakes.

On Sunday the 15th of June, soon after ten o'clock at night, another shock of an earthquake was felt at Naples, but did not appear to be quite so violent as that of the 12th, nor did it last so long; at the same moment a fountain of bright fire, attended with a very black smoke and a loud report, was seen to issue, and rise to a great height, from about the middle of the cone of Vesuvius; soon after another of the same kind broke out at some little distance lower down; then, as is supposed by the blowing up of a covered channel full of red hot lava, it had the appearance as if the lava had taken its course directly up the steep cone of the volcano. Fresh fountains succeeded one another hastily, and all in a direct line tending, for about a mile and a half down, towards the towns of Resina and Torre del Greco. Sir William Hamilton could count fifteen of them, and believes there were others obscured by the smoke. It seems probable, that all these fountains of fire, from their being in such an exact line, proceeded from one and the same long fissure down the flanks of the mountain, and that the lava and other volcanic matter forced its way out of the widest parts of the crack, and formed there the little mountains and craters that will be described in their proper place. It is impossible that any description can give an idea of this fiery scene, or of the horrid noises that attended this great operation of nature. It was a mixture of the loudest thunder, with incessant reports, like those from a numerous heavy artillery, accompanied by a continual hollow murmur, like that of the roaring of the ocean during a violent storm; and, added to these was another blowing noise, like that of the ascending of a large flight of sky-rockets, or that which is produced by the action of the enormous bellows on the surface of the Carron iron foundery in Scotland. The frequent falling of the huge stones and scoriæ, which were thrown up to an incredible height from some of the new mouths, and one of which having been since measured by the Abbé Tata was ten feet high, and thirty-five in circumference, contributed undoubtedly to the concussion of the earth and air, which kept all the houses at Naples for several hours in a constant tremor, every door and window shaking and rattling incessantly, and the bells ringing. This was an awful moment! The sky, from a bright full moon and star-light, began to be obscured; the moon had presently the appearance of being in an eclipse, and soon after was totally lost in obscurity. The murmur of the prayers and lamentations of a numerous populace forming various processions, and parading in the streets, added to the horror. As the lava did not appear to have yet a sufficient vent, and it was now evident that the earthquakes already felt had been occasioned by the air and fiery matter confined within the bowels of the mountain, and probably at no small depth (considering the extent of those earthquakes) Sir William recommended to the company that was with him, who began to be much alarmed, rather to go and view the mountain at some greater distance, and in the open air, than to remain in the house, which was on the sea-side, and in the part of Naples that is nearest and most exposed to Vesuvius. They accordingly proceeded to Posilipo, and viewed the conflagration, now become still more considerable, from the sea-side under the mountain; but whether from the eruption having increased, or from the loud reports of the volcanic explosions being repeated by the mountain behind them, the noise was much louder, and more alarming than that they had heard in their first position. After some time, and which was about two o'clock in the morning of the 16th, having observed that the lavas ran in abundance, freely, and with great velocity, having made a considerable progress towards Resina, the town which it first threatened, and that the fiery vapours which had been confined had now free vent through many parts of a crack of more than a mile and a half in length, as was evident from the quantity of inflamed matter and black smoke, which continued to issue from the new mouths above-mentioned, without any interruption, our author concluded that at Naples all danger from earthquakes, which had been his greatest apprehension, was totally removed, and he returned to his former station at St. Lucia at Naples.

All this time there was not the smallest appearance of fire or smoke from the crater on the summit of Vesuvius; but the black smoke and ashes issuing continually from so many new mouths, or craters, formed an enormous and dense body of clouds over the whole mountain, and which began to give signs of being replete with the electric fluid, by exhibiting flashes of that sort of zig-zag lightning, which in the volcanic language of the country is called *ferilli,* and which is the constant attendant on the most violent eruptions.

Sir William Hamilton proceeds to remark, that during thirty years that he had resided at Naples, and in which space of time he had been witness to many eruptions of Vesuvius, of one sort or other, he never saw the cloud of smoke so replete with the electric fire, except in the two great eruptions of 1767, that of 1779, and during this more formidable one. The electric fire, in the year 1779, that played constantly with the enormous black cloud over the crater of Vesuvius, and seldom quitted it, was exactly similar to that which is produced, on a small scale, by the conductor of an electrical machine communicating with an insulated plate of glass, thinly spread over with metallic filings, &c. when the electric matter continues to play over it in zig-zag lines without quitting it. He was not sensible of any noise attending that operation in 1779; whereas the discharge of the electrical matter from the volcanic clouds during this eruption, and particularly the second and third days, caused explosions like those of the loudest thunder; and indeed the storms raised evidently by the sole power of the volcano, resembled in every respect all other thunder-storms; the lightning falling and destroying every thing in its course. The house of the Marquis of Berio at St. Jorio, situate at the foot of Vesuvius, during one of these volcanic storms was struck with lightning, which having shattered many doors and windows, and damaged the furniture, left for some time a strong smell of sulphur in the rooms it passed through. Out of these gigantic and volcanic clouds, besides the lightning, both during this eruption and that of 1779, the author adds, he had, with many others, seen balls of fire issue, and some of a considerable magnitude, which bursting in the air, produced nearly the same effect as that from the air-balloons in fire-works, the electric fire that came out having the appearance of the serpents with which those fire-work balloons are often filled. The day on which Naples was in the greatest danger from the volcanic clouds, two small balls of fire, joined together by a small link like a chain-shot, fell close to his Casino at Posilipo; they separated, and one fell in the vineyard above the house, and the other in the sea, so close to it that he heard the splash in the water. The Abbé Tata, in his printed account of this eruption, mentions an enormous ball of this kind which flew out of the crater of Vesuvius while he was standing on the edge of it, and which burst in the air at some distance from the mountain, soon after which he heard a noise like the fall of a number of stones, or of a heavy shower of hail. During the eruption of the 15th at night, few of the inhabitants of Naples, from the dread of earthquakes, ventured to go to their beds. The common people were either employed in devout processions in the streets, or were sleeping on the quays and open places; the nobility and gentry, having caused their horses to be taken from their carriages, slept in them in the squares and open places, or on the high roads just out of the town. For several days, while the volcanic storms of thunder and lightning lasted, the inhabitants at the foot of the volcano, both on the sea side and the Somma side, were often sensible of a tremor in the earth, as well as of the concussions in the air, but at Naples only the earthquakes of the 12th and 15th of June were distinctly and universally felt: this fair city could not certainly have resisted, had not those earthquakes been fortunately of a short duration. Throughout this eruption, which continued in force about ten days, the fever of the mountain, as has been remarked in former eruptions, showed itself to be in some measure periodical, and generally was most violent at the break of day, at noon, and at midnight.

About four o'clock in the morning of the 16th, the crater of Vesuvius began to show signs of being open, by some black smoke issuing out of it; and at day-break another smoke, tinged with red, issuing from an opening near the crater, but on the other side of the mountain, and facing the town of Ottaiano, shewed that a new mouth had opened there, from which a considerable stream of lava issued, and ran with great velocity through a wood, which it burnt; and having run about three miles in a few hours, it stopped before it had arrived at the vineyards,and cultivated lands. The crater, and all the conical part of Vesuvius, was soon involved in clouds and darkness, and so it remained for several days; but above these clouds, although of a great height, fresh columns of smoke were seen from the crater, rising furiously still higher, until the whole mass remained in the usual form of a pine-tree; and in that gigantic mass of heavy clouds the ferilli, or volcanic lightning, was frequently visible, even in the day time. About five o'clock in the morning of the 16th, the lava which had first broken out from the several new mouths on the south side of the mountain, had reached the sea, and was running into it, having overwhelmed, burnt, and destroyed the greatest part of Torre del Greco, the principal stream of lava having taken its course through the very centre of the town. They observed from Naples, that when the lava was in the vineyards in its way to the town, there issued often, and in different parts of it, a bright pale flame, and very different from the deep red of the lava; this was occasioned by the burning of the trees that supported the vines. Soon after the beginning of this eruption, ashes fell thick at the foot of the mountain, all the way from Portici to the Torre del Greco; and what is remarkable, although there were not at that time any clouds in the air, except those of smoke from the mountain, the ashes were wet, and accompanied with large drops of water, which were to the taste very salt; the road, which is paved, was as wet as if there had been a heavy shower of rain. Those ashes were black and coarse, like the sand of the sea-shore; whereas those that fell there, and at Naples some days after, were of a light grey colour, and as fine as Spanish snuff, or powdered bark. They contained many saline particles; those ashes that lay on the ground, exposed to the burning sun, had a coat of the whitest powder on their surface, which to the taste was extremely salt and pungent. In the printed account of the eruption by Emanuel Scotti, doctor of physic and professor of philosophy in the university of Naples, he supposes (which appears to be highly probable) that the water which accompanied the fall of the ashes at the beginning of the eruption, was produced by the mixture of the inflammable and dephlogisticated air.

By the time that the lava had reached the sea, between five and six o'clock in the morning of the 16th, Vesuvius was so completely involved in darkness, that the violent operation of nature that was going on there could no longer be discerned, and so it remained for several days; but the dreadful noise, and the red tinge on the clouds over the top of the mountain, were evident signs of the activity of the fire underneath. The lava ran but slowly at Torre del Greco after it had reached the sea; and on the 17th of June in the morning, its course was stopped, excepting that at times a little rivulet of liquid fire issued from under the smoaking scoriæ into the sea, and caused a hissing noise, and a white vapour smoke; at other times, a quantity of large scoriæ were pushed off the surface of the body of the lava into the sea, discovering that it was red hot under that surface; and even to the latter end of August, the center of the thickest part of the lava that covered the town retained its red heat. The breadth of the lava that ran into the sea, and formed a new promontory there, after having destroyed the greatest part of the town of Torre del Greco, having been exactly measured by the duke della Torre, is of English feet 1204. Its height above the sea is twelve feet, and as many feet under water; so that its whole height is twenty-four feet; it extends into the sea 626 feet. The sea water was boiling as in a cauldron, where it washed the foot of this new formed promontory: and, although our author was at least a hundred yards from it, observing that the sea smoked near his boat, he put his hand into the water, which was literally scalded; and by this time his boatmen observed that the pitch from the bottom of the boat was melting fast, and floating on the surface of the sea, and that the boat began to leak; he therefore retired hastily from this spot, and landed at some distance from the hot lava. The town of Torre del Greco contained about eighteen thousand inhabitants, all of whom (except about fifteen, who, from either age or infirmity, could not be moved, and were overwhelmed by the lava in their houses), escaped either to Castel-a-mare, which was the ancient Stabiæ, or to Naples; but the rapid progress of the lava was such, after it had altered its course from Resina, which town it first threatened, and had joined a fresh lava that issued from one of the new mouths, in a vineyard, about a mile from the town, that it ran like a torrent over the town of Torre del Greco, allowing the unfortunate inhabitants scarcely time to save their lives; their goods and effects were totally abandoned, and indeed several of the inhabitants, whose houses had been surrounded with lava, while they remained in them, escaped from them, and saved their lives the following day, by coming out of the tops of their houses, and walking over the scoriæ on the surface of the red hot lava. Five or six old nuns were taken out of a convent in this manner on the 16th of June, and carried over the hot lava; their stupidity was such as not to have been the least alarmed, or sensible of their danger: one of upwards of ninety years of age was found actually warming herself at a point of red hot lava, which touched the window of her cell, and which she said was very comfortable; and, though now apprized of their danger, they were still very unwilling to leave the convent, in which they had been shut up almost from their infancy, their ideas being as limited as the space they inhabited. Having been desired to pack up whatever they had that was most valuable, they all loaded themselves with biscuits and sweetmeats, and it was but by accident it was discovered that they had left a sum of money behind them, which was recovered for them.

The lava passed over the centre and best part of the town; no part of the cathedral remained above it, except the upper part of a square brick tower, in which were the bells; and it is a curious circumstance, that those bells, although they were neither cracked nor melted, were deprived of their tone as much as if they had been cracked. When the lava first entered the sea, it threw up the water to a prodigious height; and particularly when two points of lava met and inclosed a pool of water, that water was thrown up with great violence, and a loud report: at this time, as well as the day after also, a great many boiled fish were seen floating on the surface of the sea.

The lava over the cathedral, and in other parts of the town, is said to be upwards of forty feet in thickness; the general height of the lava during its whole course was about twelve feet, and in some parts not less than a mile in breadth.

When Sir William Hamilton visited it on the 17th of June, the tops of the houses were just visible here and there in some parts, and the timbers within still burning caused a bright flame to issue out of the surface; in other parts, the sulphur and salts exhaled in a white smoke from the lava, forming a white or yellow crust on the scoriæ round the spots where it issued with the greatest force. He often heard little explosions, and saw that they blew up, like little mines, fragments of the scoriæ and ashes into the air; these he supposes to have been occasioned either by rarefied air in confined cellars, or, perhaps, by small portions of gunpowder taking fire, as few in that country are without a gun and some little portion of gunpowder in their houses. As the church feasts there are usually attended with fireworks and crackers, a firework-maker of the town had a very great quantity of fireworks ready made for an approaching feast, and some gunpowder, all of which had been shut up in his house by the lava, a part of which had even entered one of the rooms; yet he actually saved all his fireworks and gunpowder some days after, by carrying them safely over the scoriæ of the lava, that was red hot underneath. The heat in the streets of the town, at this time, was so great as to raise the thermometer to very near one hundred degrees, and close to the hot lava it rose much higher. Sir William remarked in his way home, that there was a much greater quantity of the petroleum floating on the surface of the sea, and diffusing a very strong and offensive smell, than was usual; for at all times in calms, patches of this bituminous oil are to be seen floating on the surface of the sea between Portici and Naples, and particularly opposite a village called Pietra Bianca. The minute ashes continued falling at Naples; and the mountain, totally obscured by them, continued to alarm the inhabitants with repeated loud explosions.

On Wednesday June 18, the wind having for a short space of time cleared away the thick cloud from the top of Vesuvius, it was now discovered that a great part of its crater, particularly on the west side opposite Naples, had fallen in, which it probably did about four o'clock in the morning of that day, as a violent shock of an earthquake was felt at that moment at Resina, and other parts situate at the foot of the volcano. The clouds of smoke, mixed with the ashes, were of such a density as to appear to have the greatest difficulty in forcing their passage out of the now widely extended mouth of Vesuvius, which certainly, since the top fell in, cannot be much short of two miles in circumference. One cloud heaped on another, and succeeding one another incessantly, formed in a few hours such a gigantic and elevated column of the darkest hue over the mountain, as seemed to threaten Naples with immediate destruction, having at one time been bent over the city, and appearing to be much too massive and ponderous to remain long suspended in the air; it was besides replete with the ferilli, or volcanic lightning, which was stronger than common lightning, just as Pliny the younger describes it in one of his letters to Tacitus, when he says *fulgoribus illæ et similes et majores erant.*

Vesuvius was at this time completely covered, as were all the old black lavas, with a thick coat of those fine light-grey ashes already fallen, which gave it a cold and horrid appearance; and in comparison of the above-mentioned enormous mass of clouds, which certainly, however it may contradict our idea of the extension of our atmosphere, rose many miles above the mountain, it appeared like a molehill, although the perpendicular height of Vesuvius, from the level of the sea, is more than three thousand six hundred feet. The Abbé Braccini, as appears in his printed account of the eruption of Mount Vesuvius in 1631, measured with a quadrant the elevation of a mass of clouds of the same nature, that was formed over Vesuvius during that great eruption, and found it to exceed thirty miles in height. Dr. Scotti, in his printed account of this eruption, says, that the height of this threatening cloud of smoke and ashes, measured from Naples, was found to be of an elevation of thirty degrees.

The storms of thunder and lightning, attended at times with heavy falls of rain and ashes, causing the most destructive torrents of water and glutinous mud, mixed with huge stones, and trees torn up by the roots, continued more or less to afflict the inhabitants on both sides of the volcano until the 7th of July, when the last torrent destroyed many hundred acres of cultivated land, between the towns of Torre del Greco and Torre dell' Annunziata. Some of these torrents, both on the sea side and the Somma side of the mountain, came down with a horrid rushing noise; and some of them, after having forced their way through the narrow gullies of the mountain, rose to the height of more than twenty feet, and were near half a mile in extent. The mud, of which the torrents were composed, being a kind of natural mortar, completely cased up and ruined some thousand acres of rich vineyards; for it soon becomes so hard, that nothing less than a pickaxe can break it up.

The laudable curiosity of our author induced him to go upon Mount Vesuvius, as soon as it was consistent with any degree of prudence, which was not until the 30th of June, and even then it was attended with some risk. The crater of Vesuvius, except at short intervals, had been continually obscured by the volcanic clouds from the 16th, and was so on that day, with frequent flashes of lightning playing in those clouds, and attended as usual with a noise like thunder; and the fine ashes were still falling on Vesuvius, but still more on the mountain of Somma. Sir William went up the usual way by Resina, and observed, in his way through that village, that many of the stones of the pavement had been loosened, and were deranged by the earthquakes, particularly by that of the 18th, which attended the falling in of the crater of the volcano, and which had been so violent as to throw people down, and obliged all the inhabitants of Resina to quit their houses hastily, to which they did not dare return for two days. The leaves of all the vines were burnt by the ashes that had fallen on them, and many of the vines themselves were buried under the ashes, and great branches of the trees that supported them had been torn off by their weight. In short, nothing but ruin and desolation was to be seen. The ashes at the foot of the mountain were about ten or twelve inches thick on the surface of the earth, but in proportion as he ascended, their thickness increased to several feet, not less than nine or ten in some parts; so that the surface of the old rugged lavas, that before was almost impassible, was now become a perfect plain, over which he walked with the greatest ease. The ashes were of a light-grey colour, and exceedingly fine, so that by the footsteps being marked on them as on snow, he learnt that three small parties had been up before him. He saw likewise the track of a fox, which appeared to have been quite bewildered, to judge from the many turns he had made. Even the traces of lizards and other little animals, and of insects, were visible on these fine ashes. Sir William and his companion ascended to the spot whence the lava of the 15th first issued, and followed

" From which circumstances it seems very probable to conclude, that it proceeded from some such subterraneous inkindling as resembles *gunpowder*,* both by the noise it yielded, and in the suddenness of its firing, and its

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the course of it, which was still very hot (although covered with such a thick coat of ashes) quite down to the sea at Torre del Greco, which is more than five miles. It was not possible to get up to the great crater of Vesuvius, nor had any one yet attempted it. The horrid chasms that existed from the spot where the late eruption first took place, in a straight line for near two miles toward the sea, cannot be imagined. They formed vallies more than two hundred feet deep, and from half a mile to a mile wide; and where the fountains of fiery matter existed during the eruption, were little mountains with deep craters. Ten thousand men, in as many years, could not make such an alteration on the face of Vesuvius. Except the exhalations of sulphureous and vitriolic vapours, which broke out from different spots of the line above-mentioned, and tinged the surface of the ashes and scoriæ in those parts with either a deep or pale-yellow, with a reddish ochre colour, or a bright white, and in some parts with a deep green and azure blue (so that the whole together had the effect of an iris), all had the appearance of a sandy desart. Our adventurers then went on the top of seven of the most considerable of the new-formed mountains, and looked into their craters, which on some of them appeared to be little short of half a mile in circumference; and although the exterior perpendicular height of any of them did not exceed two hundred feet, the depth of their inverted cone within was three times as great. It would not have been possible to have breathed on these new mountains near their craters, if they had not taken the precaution of tying a double handkerchief over their mouths and nostrils; and even with that precaution they could not resist long, the fumes of the vitriolic acid were so exceedingly penetrating, and of such a suffocating quality. They found in one a double crater, like two funnels joined together; and in all there was some little smoke and depositions of salts and sulphurs, of the various colours above-mentioned, just as is commonly seen adhering to the inner walls of the principal crater of Vesuvius.

The reader of sensibility will not object to the length of these notes, exhibiting the most grand and wonderful works of an Almighty power, in a part where the philosophic principles, relatively connected with Botany, are subjects under discussion. We hope and expect, that on this account, the eager inquirer into the science of Botany will excuse what he may judge to be an intrusion on a topic he might feel, at the present time, more anxious to be instructed in.

* Gunpowder, the most terrible engine invented for the destruction of life, whereby mortals imitate the august armoury of the Deity, is generally supposed to be the discovery of Roger Bacon, who died in 1291. Fearful of the mischievous uses, that might arise from this invention, he describes it in mysterious characters, omitting the most essential ingredient. His words are, " Ope salis petræ, sulphuris, et *Lure mope can ubre*, facies, si scias tonitrum, et coruscationem artificium." " By means of salt-petre, sulphur, and Lure mopo can ubre, you can make an artificial thunder and lightning." The barbarous words *Lure mopo can ubre*, are now known to be an anagram for carbonum pulvere, and he mentions " the possibility of its application for overturning cities and empires." Too faithfully has this been verified, but the author of such an application is concealed from us. Polydore Virgil, who appears to have known him, says, " a German, whose birth was ignoble, and whose name I hope never will be handed down to posterity, invented an iron tube, for containing of gunpowder, which was employed by the Venetians in the year 1380." By the Venetians, the use of gunpowder, says Gibbon, was communicated without reproach to the Sultan of Egypt and Persia, their allies against the Ottoman power; the *secret* was soon propagated to the extremities of Asia, and the advantages of the strong and skilful over the weak and unpractised, was annihilation in an instant. Before the end of the century in which it was introduced, it became familiar to all the states in Germany, Italy, Spain, France, and England. If we contrast, continues the historian, the rapid progress of this mischievous invention with the slow and laborious advances of reason, science, and the arts of peace, a philosopher, according to his temper, will either *laugh* or *weep at the folly of mankind*. To contemplate the tremendous power as a chemist, is fortunately our province, for war

powerful expansion when fired; for the noise was as of *many cannon*; this alone proves it to be very sudden.

" The materials of these earthquakes may be different, but their effects will be the same; just as we find the *pulvis fulminans*, as it is called, which hath some of its materials differing from that of common powder; as also *aurum fulminans*, which is yet more differing, both as to its materials and as to its way of kindling, have yet most of the same effects with gunpowder, both as to the flashing and thundering noise, and as to the force or violence. So that as these are differing in many particulars, and yet produce much the same effects, so it is probable, that what is the cause of earthquakes and subterraneous thundering, flashings, and violent expansion, as I may so call those phænomena observable in those *crises* of nature, may be in divers particulars differing from every one of these, both as to the materials, and as to the form and manner of ascension, and yet as to the effects, they may be very analogous and similar. So that though I cannot possi-

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but too much resembles those natural calamities, whose causes we at present are endeavouring to investigate, as if the miseries of our condition were not enough, without this addition to them of our own contriving!

Gunpowder contains a large proportion of nitre, less of charcoal, and a very trifling quantity of sulphur. An hundred pounds of gunpowder possesses seventy-five pounds of nitre, fifteen of charcoal, and ten of sulphur. This mixture is triturated for ten or twelve hours in wooden mortars, with pestles of the same substance; and a small proportion of water is at the same time added. It is then passed through several skin sieves to be granulated. The granulated powder is next rested to separate the dust, and being then put into a cask by the motion of its parts, the cask being turned by a wheel, it becomes glazed, or polished. Chemists and natural philosophers have entertained various opinions concerning the violent explosion produced by gunpowder. Some have supposed it to arise from water turned into vapour, others to the sudden augmentation of the air. But Ingenhousz seems to have given the best explanation of the phœnomenon, which will be found hereafter exactly to correspond with the able conjecture of Hook.

The Abbé Fortana first discovered that an ounce of nitre gave out by the means of fire about eight hundred cubic inches of the purest oxygen air: also that an ounce of charcoal heated in a retort, gave out about an hundred and fifty cubic inches of inflammable air mixed with a small proportion of fixed air. Dr. Ingenhousz put together these two experiments, and calculated the quantity of gas extricated from a cubic inch of gunpowder at the moment of ascension, which must amount to five hundred and sixty-nine cubic inches of other elastic fluids. And as these must occupy four times this space at the degree of heat they must experience, hence it follows, that the air extricated from a cubic inch of gunpowder must occupy at least two thousand two hundred and sixty-six cubic inches. Besides this, the inflammable air unites with the oxygen air, and produces fresh heat, and vapour, and hence that quick and powerful expansion, pressing most where the resistance is least, and pursuing the ball in the cavity along which it runs. May not the inflammable air in part, arise from the water of crystallization in the nitre? as it forms one part, out of an hundred, in the producing of gunpowder. As to the sulphur, this appears to have no other use than the speedier and more certain ascension of the powder: for the poachers, says Mr. Robins, an ingenious writer, are in the practice of depriving powder of its sulphur by heating it with warm ashes in a tin plate; and they imagine that by this means the force of the powder is increased, and the arms less injured by use.

bly prove what the materials are, yet the effects speak them to be somewhat analogous to those of gunpowder, or *pulvis fulminans, aurum fulminans*[*] or lightning, which, though they seem very differing in many particulars, yet when I come to shew the causes and reasons of those effects, I shall manifest, that it is but one operation in nature, and that which causes the effect in one causes the effect in all the rest; and the outward appearances of the differing materials, and the different way of operating, are nothing but the habits, and dresses, and visors of the actors, and the differing modes and postures by which they act their several parts, which, when they have done, they are at an end, and have exerted their whole power, and there must be a new set of actors to do the same thing again; the oil of the lamp will be turned all into flame, but you must have fresh oil, if you will have the flame continued. So the materials that make the subterraneous flame of fire, or expansion, call it by which name you please, is consumed and converted to another substance, not fit to produce any more the same effect; and if the conflagration be so great as to consume all the present store, you might safely conclude that place would no more be troubled with such effects; but if there be remainders, either already fit and prepared, but sheltered from ascension by other interposing incombustible materials; or that there be other parts not thoroughly ripe, and sufficiently prepared for such ascension, concurrence of after causes may repeat the same effects, and that *toties quoties* till all the mine be exhausted, which I look upon as a thing not only possible, but probable, nay, necessary, for that I find it to be the general method of nature, which is always going forward, and continually making a progress of changing all things from the state in which it finds them at the present; all things as they proceed to their perfection, so they proceed also to their dissolution and corruption, as to their proceeding estate; and where nature repeats the process, it is always on a new individual.

" It is very remarkable that the Isle of Modunda, which it seems is all an uninhabited rock, was split, and a part of it tumbled down and sunk into the sea; upon which occasion it seems it made a prodigious noise as of many cannon, and sending up at the same time a great cloud of dust, as they term it, which, in probability, was also mingled with smoke, which puts me in mind of the Phænomena I observed lately, when the powder-mill and magazine at Hackney blew up; for besides the very great noise of the blow which I heard, being within a mile of it, in the fields, I observed immediately, a great white cloud of smoke to rise in a body to a great height in the air, and to be carried by the wind for two miles and better without dispersing or falling down, but perfectly resembling the white summer clouds: but this only by the bye. From these Phænomena of the earthquake it seems very probable, that it proceeded from such subterraneous inkindling as resembles gunpowder, both by the noise it yielded, and in the suddenness of its firing, and its powerful expansion when fired; for the noise was as of many cannon; this alone proves it to be very sudden.

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[*] Gold is not attacked by the *sulphuric acid*, and is very slightly acted on by the *nitric acid*; but is attacked with most energy by the *nitro-muriatic* acid, or *aqua regia*, as it is called, and the *oxy-mu-*

"Next the splitting of the rocky island proves its power to be very great; this is proved yet farther by the blow and strokes it communicated to the sea, and so to the ships that sailed upon it; for no slow motion whatever could have communicated such a concussion through the water to the vessels upon it; but it must be as sudden as that of powder, otherwise the stroke of the earth upon the incumbent seas, would never have had the like success; for if it had been a gradual rising of the bottom, the sea would gradually have run off from it, and upon its sinking again have gradually returned, and the vessels on it would only have been sensible at most but of a current or running of the water to or from the place sinking or rising, somewhat like the effect that happened at Nevis; which doth plainly shew, that, besides the sudden strokes

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riatic acid, which are the true solvents of gold. This solution yields yellow crystals, resembling topazes, in truncated octahedra, these crystals being a true MURIATE OF GOLD. It tinges animal substances purple, and by distillation, yields a red liquor, called by the adepts, *the red lion.* An OXIDE OF GOLD is precipitated from this solution, in a *yellow powder*, nearly in a metallic state, by *lime, magnesia,* and by *alkalies*; the precipitate being soluble in the *sulphuric, nitric,* and *muriatic acids.*

When precipitated by *ammoniac* from the yellow solution, it is called FULMINATING GOLD, it detonating when gently heated. Fulminating gold has been proved to be a mixture of ammoniac, and oxide of gold; the oxygen of the latter, and the hydrogen of the alkali taking fire by simple heat, detonate; and the gold is restored to its metallic state.

Nitriated silver, being precipitated from its solution, separated from the fluid, exposed three days to the air and light, and mixed with liquid ammoniac, becomes, when dry, FULMINATING SILVER. This exceeds in power, gunpowder, and even fulminating gold. Once obtained, it can no longer be touched without a violent detonation, no more than one grain being sufficient to give rise to a dangerous fulmination; after this fulmination, the silver is found reduced or revivified, its oxygen having combined with the hydrogen of the ammoniac, by which water, in the state of vapour, is produced. This water, instantly vaporized, and possessing all the elasticity, and expansive force of that state, is the principal cause of the phænomenon; in which the nitrogen of the ammoniac, with its whole expansibility, bears a part. Vide an excellent Compendium of Chemistry by the ingenious JAMES PARKINSON, surgeon.

or concussions, there was also a considerable rising and sinking of the whole island as to the level of the sea.

"But that which I principally note under this head is, that a good part of the said island tumbled down and was sunk into the sea, which gives an account how many parts of the earth come to be buried under ground and displaced from their former situations, and thence how ships' anchors, bones, teeth, &c. that have sometimes been digged up from great depths, may have come to be there buried.

"It is very remarkable also, that this eruption sent up into the air great clouds of dust and smoke, which for the most part must soon fall down again into the sea, or contiguous parts of the island. This will give a probable account how the layers of the superficial parts of the earth may come to be made; for the bigger part of this dust must come down to the bottom first, and settle to a certain thickness and make a bed of gravel, then will follow beds of coarse sand, then beds of finer and finer sand, and last of clays or moulds of several sorts; again much of that which fell upon the higher parts of the island, will, by the rivers, be washed down into the vales, and there produce the like beds or layers of several kinds, and so bury many of the parts that were before on the surface. Thus plants and vegetable substances may come to be buried, and the bones and teeth of the carcasses of dead animals: these may also sometimes be buried under beds or crusts of stone, when the parts that thus make the layers chance to be mixed with such subterraneous substances as carry with them a petrifying quality.

"What is most remarkable in these earthquakes in the Leeward islands, is, that they have all happened to places not far distant from the sea, or even under the sea itself, though the eruptions have been, for the most part on the land. So that there doth seem to be somewhat of reason to conjecture as *Signior Bottoni* in his *Pyrologia Topographica*, that the saline quality of the sea-water may conduce to the producing of the subterraneous fermentation with the sulphureous minerals there placed, which the experiment lately here exhibited at a meeting of this society, does yet make more probable: for by that it was evident, that the mixing of spirit of salt with iron, did produce such a fermentation as did produce a vapour or steam, which by an actual flame was immediately fired like gunpowder *, and if inclosed, would, in all probability, have had a like effect of raising and dispersing of those parts that bounded and imprisoned it. Now, it is evident that the melted matter which was vomited out of *Ætna* in the year sixty-nine (of which we have a part now in the repository) was very much like to melted or cast *iron*, and I doubt not but that there may be much of that mineral in it; besides, the foot of that mountain does extend even to the very *sea*, and in all probability may have caverns under the sea itself, which is argued also from the concurrency of the conflagration of *Strombolo* and *Lipary*, islands considerably distant by sea, at the same time, it is generally believed that there may be subterraneous cavernous passages between them, by which they communicate to one another; so that sometimes it begins in *Ætna*, and is communicated to *Strombolo*, and reciprocally to *Mongibel*.

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* This is the first account we have of the production of *inflammable air* (HYDROGEN GAS).

" This possibly may afford a probable reason why islands are now more subject to earthquakes than continents and inland parts; and indeed how so many islands came to be dispersed up and down in the sea, namely, for that these fermentations may have been caused in the parts of the earth subjacent to the sea, which being brought to a head of ripeness, may have taken fire, and so have had force enough to raise a sufficient quantity of the earth above it, to make its way through the sea, and there make itself a vent, as that of the *Canaries* did in the year thirty-nine, which, if sufficiently copious, may produce an island as that did also for a time, though it hath since that time again sunk under the surface of the sea:* but the island of *Ascension*, which, by all appearances, doth seem to have been the same way produced, doth still remain as a witness to prove this hypothesis.* A like testimony to this, of the cause and manner of their production, I take the island and pike of *Tenariff* to be, so *Hecla* of *Iceland*, so *Bearenberg* of *John Mayens* or *Trinity Island*, so *del Fuego* of the Icelands of *Cape Verd*, so *Ternate* of the *Moluccas*; and the island of *Mascarenas*, of the islands about *Madagascar* among the *Antillas* or *Caribes*, all which do seem to me to be remaining testimonies how, and in what manner, and by what means those other islands which have now worn out the marks of their first origination, were at first produced. And though the fires be extinct in many of the other islands, yet it is observable, that the prodigious high mountains or sugar-loaf pikes or hills do yet remain as marks of what they had been heretofore; so the pike of *Fayal* among the *Terceras*, and the whole island of St. *Helena*, and several others of those about *Madagascar* and of the *East Indies*, and of those of the *Antilles*, and that of St. *Martha* mentioned by *Dampier*, do seem to me to be plain evidences of the former and original causes of them all.

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* The swallowing up of islands by Volcanos is, we suppose, represented by the story of PROSERPINE.

Thus in *Sicilia's* ever-blooming shade
When playful PROSERPINE from CERES stray'd,
Led with unwary steps her virgin trains
O'er *Ætna's* steeps, and *Enna's* golden plains;
Pluck'd with fair hand the silver-blossom'd bower,
And purpled mead,—herself a fairer flower;
Sudden, unseen amid the twilight glade,
Rush'd gloomy DIS, and seiz'd the trembling maid.
Her starting damsels sprung from mossy seats,
Dropp'd from their gauzy laps the gather'd sweets,
Clung round the struggling nymph, with piercing cries
Pursu'd the chariot, and invok'd the skies;—
Pleas'd as HE grasps her with HIS iron arms,
Frights with soft sighs, with tender words alarms,
The wheels descending roll'd in smoky rings,
Infernal *Cupids* flapp'd their demon wings;
Earth with deep yawn receiv'd the fair, amaz'd,
And far in night, celestial beauty blaz'd.

DARWIN.

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* New islands are formed in two ways; either suddenly, by the action of subterraneous fires; or more slowly, by the deposition of mud, carried down by rivers, and stopped by some accident. With respect particularly to the first, ancient historians, and modern travellers, give us such accounts as we can have no room to doubt of.

"On the twenty-fourth of May, in the year 1707, a slight earthquake was perceived at *Santorin*; and the day following, at sun-rising, an object was seen by the inhabitants of that island, at two or three miles distance at sea, which appeared like a floating rock. Some persons, desirous either of gain, or excited by curiosity, went there, and found, even while they stood upon this rock, that it seemed to rise beneath their feet. They perceived also that its surface was covered with pumice stones and oysters, which it had raised from the bottom. Every day after, until the fourteenth of June, this rock seemed considerably to increase; and then was found to be half a mile round, and about thirty feet above the sea. The earth of which it was composed seemed whitish, with a small portion of clay. Soon after this the sea again appeared troubled, and steams arose, which were very offensive to the inhabitants of *Santorin*. But on the sixteenth of the succeeding month, seventeen or eighteen rocks more were seen to rise out of the sea, and at length to join together. All this was accompanied with the most terrific noise, and fires which proceeded from the island that was newly formed. The whole mass, however, of all this new-formed earth, uniting, increased every day, both in height and breadth, and, by the force of its explosions, cast forth rocks to seven miles distance. This continued to bear the same dreadful appearances till the month of November in the same year; and it is at present a volcano which sometimes renews its explosions. It is about three miles in circumference, and more than from thirty-five to forty feet high." Hist. de l'Acad. an. 1708, p. 23.

It seems extraordinary, that about this place in particular, islands have appeared at different times, particularly that of Hiera, mentioned above, which has received considerable additions in succeeding ages. Justin tells us, that at the time the Macedonians were at war with the Romans, a new island appeared between those of Theramenes and Therasia, by means of an earthquake. We are told, that this became half as big again about a thousand years after; another island rising up by its side, and joining to it, so as scarce at present to be distinguished from the former.

The ancients who clothed in figure all the great phænomena of nature, represented this formation of islands, by the beautiful Fable of VENUS (who was wedded to VULCAN) rising out of the ocean,

Now, on her beryl throne by Tritons borne,
Bright rose THE GODDESS like the Star of Morn;
When with soft fires the mighty dawn he leads,
And wakes to life and love the laughing meads;—
With rosy fingers, as uncurl'd they hung
Round her fair brow, her golden locks she wrung;
O'er the smooth surge on silver sandals stood,
And look'd Enchantment on the dazzling flood,
The bright drops rolling from her lifted arms,
In slow meanders wander o'er her charms,
Seek round her snowy neck their lucid track,
Pearl her white shoulders, gem her ivory back,
Round her fine waist and swelling bosom swim,
And star with glittering brine each crystal limb.
—The immortal form enamour'd NATURE hail'd,
And BEAUTY blazed to heaven and earth *unveil'd*.

DARWIN.

“ Nor do I in the least doubt but that an inquisitive person who should purposely survey all other islands that wanted these marks or tokens of such eruptions, might find enough of other indications * to manifest by what means they so came to be placed in the sea, so far from any part of the continents they are opposite to.

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* “ Near Reading, in Berkshire, for many succeeding generations, a continued body of oyster-shells has been found through the whole circumference of five or six acres of ground. The foundation of these shells is an hard rocky chalk; and above this chalk, the oyster-shells lie in a bed of green sand, upon a level, as nigh as possibly can be judged, and are about two feet in thickness.” (Phil. Trans. vol. ii. p. 427.)

These shells are in their natural state, but “ they were found also petrified, and almost in equal abundance, in all the Alpine rocks, in the Pyrenees, on the hills of France, England, and Flanders. Even in all quarries from whence marble is dug, if the rocks be split perpendicularly downwards, petrified shells, and other marine substances, will be plainly discerned.” (Buffon, vol. 1. p. 407.)

About a quarter of a mile from the river Medway, in the county of Kent, after the taking off the coping of a piece of ground there, the workmen came to a blue marble, which continued for three feet and an half deep, or more, and then beneath appeared an hard floor, or pavement, composed of petrified shells crowded together. This layer was about an inch deep, and several yards over; and it could be walked upon as upon a beach. These stones, of which it was composed, (the describer supposes them always to have been stones) were either wreathed as snails, or bivalvular like cockles. The wreathed kinds were about the size of an hazle-nut, and were filled with a stony substance of the colour of marle; and they themselves, also, till they were washed, were of the same colour; but when cleaned they appeared of the colour of bezoar, and of the same polish. After boiling in water they became whitish, and left a chalkiness upon the fingers. (Phil. Trans. p. 426.)

In several parts of Asia and Africa, travellers have observed these shells in great abundance. In the mountains of Castravan which lie above the city Burat, they quarry out a white stone, every part of which contains petrified fishes in great numbers, and of surprising diversity. They also seem to continue in such preservation, that their fins, scales, and all the minutest distinctions of their make, can be perfectly discerned. (Buffon, vol. i. p. 408.)

" Nor do I conceive they were all thus formed at once, but rather successively, some in one, some in other ages of the world, which may probably be in some measure collected from the quantity or thickness of the soil or mould upon them fit for vegetation; whence the island of *Ascension* may be rationally concluded to have been a production of not many ages, and the *Bermudas* also of not very many more, because of the thinness of such a soil. So also the island of *Barbadoes*, and some others, whose mould is yet but thin in respect of what it is in some others, and especially in those of greater magnitude and in the greater continents.

" Hereupon possibly it may be inquired why those greater islands and continents should be of greater antiquity than the smaller islands. To which I answer, that in the first ages of the world there were much greater magazines, or stores of the materials fitted for this purpose, which being first kindled threw up from under the sea, with which they were covered, vast quantities of it all at once, and thereupon those magazines became in a manner exhausted, yet not so totally as not to leave some smaller parcels of those substances so disposed, as not to be ready for inkindling together with those greater; besides there remained other smaller parcels of it disposed and placed in other parts of the globe sufficiently distant from them, not to be

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This disposition of shells in strata indicate their origin as connected with the sea.

Other appearances, as the bones of elephants, and other large animals, prove the *general deluge*, and this instrument of destruction was exhibited, as a tremendous proof of the omnipotency of the CREATOR of all things, and of HIS judgments.

When man too long the paths of vice pursu'd,
THY hand prepar'd the *universal flood*;
" *Withdraw thy light, thou sun! be dark, ye skies*;
" *And from the deep abyss ye waters rise!*"
The *frighted angels* heard th' Almighty LORD,
And o'er the earth from wrathful viols pour'd
Tempest and storms, obedient to his word.
Mean time his Providence to *Noah* gave
The guard of all that he design'd to save:—
Exempt from general doom *the patriarch* stood,
Contemned the waves, and triumph'd o'er the flood.

PRIOR.

For the mode in which the *deluge* was produced, vide Note * page 111.

affected or inkindled at the same time, as those I have mentioned to have been the causes of the islands far distant from the continents.

" Nor do I conceive that all those clusters were all thrown up at once, as the *Grecian* islands in the *Archipelago,* the *East-Indian* Islands in that part called the *South Sea,* the *Maldivia* near the coast of *Malabar,* the islands scattered at the North of *Madagascar,* the islands to the south-west of *St. Helena* in the *Atlantic* ocean, *Finidada dos picos,* the isles of *Cape Verd, Canaries, Orcades,* &c. also the *Gallopegas* and others in the *Pacific Sea,* or *Mar del Zur*; but rather that some were made in one age, and some in other ages of the world. And this was timed as the several magazines came to be ripened and then fired; they only indicating, as I conceive, that in those places of the terrestrial globe, there were placed the proper mineral ferments or seeds as it were of them, which, when the convenient times were come and accomplished, then they were put into act, and then they produced their effects, which are the islands that now remain the lasting monuments of them. Nor can I suppose that all the magazines of the earth of this kind are blown up and spent, but that there may be many other yet remaining for the future ages to be made sensible of their effects." Such were the conjectures of Hook.

Since the discovery of the composition of water, and our present knowledge that carbonaceous substances decompose this element, setting free its inflammable air, and that most caverns are replete with this gas*, we

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* In many of the chambers of coal-mines, notwithstanding the shafts, the *inflammable air* is so predominant that the colliers are obliged to work by the light of a machine, constructed of flints and iron, which a boy keeps turning, for this gas is not inflamed by the spark, like gunpowder, whereas it kindles in an instant from flame, and has often thus produced the most terrible destruction, before this invention of light from flint and steel was made by a steward of the late Earl of Lonsdale. The inflammable gas mixed with a certain proportion of atmospheric air may be breathed with impunity. That undaunted aerinaut Pilatre de Rozier, before a large company at Paris, inhaled it pure, and emitting it from his nostrils and mouth in the dark, set fire to the air in its passage, and realized the fabulous account of Cerberus, who is represented as vomiting out fire. Once attempting to mix it with one-ninth part of atmospheric air, and then setting it on fire, so terrible an explosion was produced, that he imagined all his teeth had been driven out. As to mixed hydrogenous air we have the authority of Spallanzani.

" On this plain it was, that, formerly, stood the furnaces on which the sulphur of Vulcano was purified. But this useful labour had been long since abandoned, and even prohibited, from the supposition that the vapours arising from the purgation of the sulphur were prejudicial to the plantations of vines in Lipari. A few years ago, indeed, it was again resumed, by the special permission of his Sicilian Majesty; but was soon again given up, not because any fear was then entertained that the vines would be injured, which the more judicious of the natives of Lipari are now convinced is a vulgar error, since they sustain no damage from the smoke of the crater of Vulcano itself, though that is beyond all comparison more in quantity than that produced by the purification of the sulphur: nor was it abandoned because the quantity of sulphur obtained was too little to repay the trouble and expence, as the vein are at no loss to suppose the production of this aerial body arising from the sea-water when it has forced its way through the sides of the volcanic cavern.

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is very rich and even inexhaustible; for wherever the ground about the craters of Vulcano and Vulcacanello is but slightly turned, fine clods of sulphur are found; which are larger and more numerous the deeper the earth is dug into. My own observations have in this particular sufficiently confirmed the testimony of the people of Lipari: as I was convinced, in my different visits to the island, that in the very places from which the sulphur had been extracted, after a short time it is re-produced.

" The real cause why the inhabitants of Lipari no longer continued this work was, that the ground, which on the surface is more or less warm, grows hotter the deeper it is dug into, and, at the depth of five or six feet, becomes so hot as to be almost insupportable; to which is to be added the offensive stench of the sulphureous fumes that issue in great abundance from these excavations. If this mineral was once extracted here to great advantage, as we are assured by history, it seems certain that these difficulties could not then exist.

" Continuing my journey towards the south from these forsaken furnaces, and having mounted a short but steep ascent, a second, but a much more spacious plain opened before me, which was every where sandy, except that a few erratic lavas were thinly scattered over it. Beyond it rose a considerable eminence, which when I had ascended, the noblest spectacle Vulcano can offer presented itself to my view, I mean its crater. Except that of Etna, I know none more capacious and majestic. It exceeds a mile in circuit, the mouth is oval, and its greatest diameter is from the south-east to the west. This mountain externally has the form of a direct cone, and its crater that of a cone inverted. The height of the internal sides from the bottom to the top is more than a quarter of a mile. From the top, the bottom may be seen, which is flat, and from many places in it exhale streams of smoke, that rise above the crater, and emit a sulphureous odour which may be perceived at a considerable distance.

" After having made the circuit of the upper circumference of the crater, I became desirous to enter it, and descended to the bottom, to examine the internal parts; the southern side, which is not very steep, appearing to invite to such examination. I was not willing however to undertake such an adventure alone, but wished for some one to accompany me, who might serve me as a guide, and, I may likewise add, who might keep up my courage. But my wishes were vain. The four sailors who had worked the boat which brought me to the island, and had gone with me to the edges of the crater, when they found I entertained thoughts of going down into it, positively refused to follow me, alledging the evident danger to which I should be exposed, and adducing the example of I know not what traveller, who, a few years ago, having descended into this deep gulph, paid for his temerity by never coming out again. All my entreaties, therefore, and all offers of reward were fruitless; and I was obliged to return to Lipari without having been able to gratify my wish. These sailors were natives of Lipari, nor could I find any of their countrymen who would hazard accompanying me in making this experiment. So great is the dread they are inspired with by this volcano, proceeding, probably, from the fame of its ancient terrors, and also from some recent eruption, of which we shall hereafter have occasion to speak.

" A resolute Calabrian, who had been banished to Lipari for some crime committed at Naples, was the only one, who, with the permission of the Marchese Chiavelli, the governor of that city, and the promise of a large reward, could be induced to go down with me into the crater. We descended on the 13th of September 1788. I have already said that the sides towards the south-east are not very steep, and on this side we therefore safely reached the bottom, where I proceeded to make such observations as I thought of most importance. I here perceived, more distinctly than I could above, that the crater was a hollow cone reversed, but truncated by the bottom on which I stood. The sides, except in that part where we descended, are every where inaccessible. As they are covered with sand, they are marked with deep furrows which are the effect of rains.

" The bottom on which we stood, may be about somewhat more than the third of a mile in circumference. It is covered with sand, like the sides, and in form an oval. I soon perceived that it could not be walked over without danger, and that it was necessary to use the greatest circumspection in examining it. I have already mentioned the subterranean noise heard on approaching the crater of

The muriatic acid of the sea-water also meeting with sulphur[*] is converted into the sulphuric acid, which in a diluted state, acts upon iron, and thus

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Vulcano. Here it may be said to be about a hundred times louder. Under this bottom we seem to hear a river running, or rather a conflict of agitated waves which meet, and impetuously clash together. The ground, likewise, in some places, cleaves in cracks, fissures and apertures, from which hissing sounds issue resembling those produced by the bellows of a furnace. I therefore thought there was every reason to conclude, that these sounds are occasioned by an elastic gas which issues through those fissures; and was afterwards perfectly convinced of the truth of this supposition by the following facts. If the hand be approached to any of these apertures, a strong impression is felt of an extremely subtle invisible fluid; and, if a lighted candle be applied to them, it will, it is true, be frequently extinguished by the impetus of the fluid, but sometimes it will set fire to the fluid itself, producing a flame of a bluish red colour which lasts for several minutes. The fetid odour which is then perceived convinced me that it is a *sulphurated hydrogenous gas*." Vide Travels in the Two Sicilies, &c.

[*] Sulphur is extracted from pyrites, an ore common to many parts of the world, and it is also found mixed with different earths, but is only met with in its pure state in the neighbourhood of volcanos, or as deposited by springs strongly impregnated with sulphur. All France, and great part of Europe, is furnished with sulphur from the mines of Solfatara in Italy, where the earth is found most to abound with this mineral.

The valley of Salfatara, near Naples, seems to exhibit, in a minute degree, whatever is seen of this horrible kind on the great theatre of nature. This plain, which is about twelve hundred feet long, and a thousand broad, is embosomed in mountains, and has in the middle of it a lake of noisome blackish water, covered with a *bitumen*, that floats upon its surface. In every part of this plain caverns appear smoking with sulphur, and often emitting flames.

This famous mine is an oval plain, the greatest diameter of which is about four hundred yards, raised about three hundred yards above the level. Almost all the surface is bare and white, like marle; and is every where sensibly warmer than the atmosphere in the greatest heat of summer; so that the feet of persons walking there are burnt through their shoes. It is impossible not to observe the sulphur there; for every where may be perceived by the smell a sulphureous vapour, which rises to a considerable height, and gives reason to believe that there is a subterraneous fire below, from which that vapour proceeds. Near the middle of this field there is a kind of bason three or four feet lower than the rest of the plain, in which a sound may be perceived when a person walks on it, as if there were under his feet some great cavity, the roof of which was very thin. After that, the lake Agnano is perceived, whose waters seem to boil. These waters are indeed hot, but not so hot as boiling water. This kind of ebullition proceeds from vapours which rise from the bottom of the lake, which being set in motion by the action of subterranean fires, have force enough to raise all that mass of water. Near this lake there are pits, not very deep, from which sulphureous vapours are exhaled. Finally, there are some deeper excavations, whence a soft stone is procured which yields sulphur. From these cavities vapours exhale, and issue out with noise, and which are nothing else than sulphur subliming through the crevices. This sulphur adheres to the sides of the rocks, where it forms enormous masses: in calm weather the vapours may be evidently seen to rise twenty-five or thirty feet from the surface of the earth. These vapours, attaching themselves to the sides of rocks, form enormous groups of sulphur, which sometimes fall down by their own weight, and render these places of dangerous access. In entering the Solfatara, there are warehouses and buildings for the refining of sulphur. Under a great shed, or hangar, supported by a wall behind, open on the other three sides, the sulphur is procured by distillation from the soft stones we mentioned above. These stones are dug from under ground; and those which lie on the surface of the earth are neglected. These last are, however, covered with a sulphur ready formed, and of a yellow colour; but the workmen say they have lost their strength, and that the sulphur obtained from them is not of so good a quality as the sulphur obtained from the stones which are dug out of the ground. These last-mentioned stones are broken in lumps, and put into pots of earthen-ware, containing each about twenty pints, Paris measure. Vide Macquer's Chemical Dictionary.

liberates a still larger quantity of the inflammable air:* or robbing the metallic oxyds of their oxygen is converted into the oxygenated muriatic acid, which has the property to form with potash, a salt, which rapidly kindles hot inflammable matter, and produces the purest *vital air* known. When these two airs are in great abundance in the hollow caverns of the earth bordering on the sea, and this *aerial gunpowder* * gets kindled, which may arise either

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In the West Indies, on the island of Guadaloupe, is a hill called La Soufriere, or the Mountain of Sulphur, which rises to a great height; the top of it is bare, nothing growing upon it but fern, and some sorry shrubs laden with moss; but it affords a fine view of Dominica, Mariagalante, Martinico, Montserrat, Nevis, and the other neighbouring islands. Upon the highest part is a rugged platform, covered with burnt stones of all sizes; and from several clefts and chinks issue smoke. On the east side are two mouths, which open into a pit of sulphur, one of which is an oval hole of about an hundred feet in its greatest diameter, out of which also frequently arise thick clouds of black smoke, accompanied with sparks of fire. The negroes who sell brimstone fetch it from this mountain. About two hundred paces below the lowest of these mouths are three pools of very hot water, four or five paces from one another: the water of the largest is very dark coloured, and smells like that in a smith's forge: the second is whitish, and has the taste of allum: the third is blue, and has a vitriolic taste.

The Marquis Ippolito, in his letter to Sir William Hamilton, which he published, relates, that immediately after the late earthquake, the waters of a well in Maida (one of the towns overthrown) of which the inhabitants used to drink, became of so strong a sulphureous taste, that it was impossible to smell to it.

* *Hydrogenous gas*, or *inflammable air*, may be extracted from all bodies in which it is a constituent part; but the purest is that afforded by the decomposition of water. For this purpose the sulphuric acid diluted with water, is poured upon iron, or zinc; and the water, which serves as a vehicle for the acid, is decomposed on the metal; its oxygen combines with it, while the hydrogenous gas escapes. This explanation, however contrary to the ancient notion, is not the less a demonstrated truth; in fact, the metal exists in the state of an oxyd in its solution by the sulphuric acid, as may be proved by precipitating it with pure vegetable alkali: on the other hand, the acid itself is not at all decomposed; so that the oxygenous gas cannot have been afforded to the iron but by the water. Water may be decomposed likewise still more directly by throwing it upon iron strongly heated; and hydrogenous gas may be obtained by causing water to pass through a tube of iron ignited to whiteness.

* Hook, as we saw, was the first to conjecture, that volcanic explosions arose from certain combinations resembling gunpowder, and that this might arise from an aerial product. His conjecture has been since amply verified, and an *aerial gunpowder* has been employed in lieu of solid forms, liberating glasses.

Fig. 18th, represents a small pistol, necessary to shew the force of exploding inflammable air. Since these instruments were introduced, their form has been very much diversified; some having been made of brass, and so large as to drive a leaden bullet; others have been made of tin, &c.; but that shewn by this figure is of glass, and so simple, that it may be easily constructed, even by persons of no great genius; and gives a sufficient idea of the power of exploding inflammable air, by driving a cork to a considerable distance.

ABD is a strong glass tube five inches long, and about half an inch in diameter. Into the inside of this tube, and towards one extremity of it, a small slip of tinfoil CB is pasted, so as to be about two inches within the tube, and be turned on the outside of it at B. Into this same extremity BD the small wire GH, knobbed at its extremity H, must be cemented very fast. The best method is to cement the wire into a small glass tube F, and then to wrap some cotton on thread round this small tube, and to cement it into the extremity BD of the pistol. The end G of the wire should be bent towards the slip of tinfoil C, so as to come within about one tenth of an inch of it. Now when this from the accession of those highly inflammable matters, called bitu-

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pistol is required to be charged, the inflammable air should be kept in a corked bottle, to the mouth of which the aperture A of the pistol must be applied very closely, in the same moment that the cork is removed, keeping the pistol inverted over it. In this case it is plain, that the common air, which is in the pistol, will mix with the inflammable air, because the former being heavier than the latter, will descend into the bottle, &c. When the pistol has been thus kept over the bottle for about ten or fifteen seconds, it must be removed, and both the pistol and the bottle must be instantly corked. If now this charged pistol be held by applying the thumb and fingers to the lower part of it, so as to touch the tinfoil B, and an electric spark be given to the knob H, by approaching it to the prime conductor of an electrical machine, or to the knob of a small charged electric phial, the inflammable air in the pistol will be fired by the spark, which will necessarily pass between G and the tinfoil C, and will drive the cork I to a considerable distance. The above-mentioned bottle filled with inflammable air is sufficient to charge the pistol several times successively, without being again filled with inflammable air, especially if it is pretty large; only it should be minded, that when the pistol has been filled out of the same bottle several times, the inflammable air in that bottle becomes mixed with a good deal of common air, for which reason the pistol should then be kept some time longer upon the bottle, in order to charge it. Sometimes the pistol will nót explode, which is owing to its having been kept too long over the bottle, so as to become filled entirely with inflammable air; the common air contained in it being descended into the bottle in consequence of its greater specific gravity.

Fig. 19th, represents a brass pistol for inflammable air, which is more commonly sold at the philosophical instrument shops. It is here represented as transparent, in order to shew its internal construction. It consists of a brass chamber ABC, to the mouth of which A a cork is fitted. To the bottom of it a perforated brass piece is screwed, into which a glass tube DE is cemented, and into this tube is cemented a wire GF, furnished with a knob F at one end, and bent at the other extremity, so as to come within about one or two tenths of an inch of the brass piece. Fig. the 20th, shews this brass piece separate, and also the brass cap I, which, when the pistol is not used, is screwed at H, in the manner shewn by the dotted line, and serves to defend the tube E. This pistol is charged and discharged in the same manner as the glass one described above, but, being much larger, it requires a greater quantity of inflammable air, and consequently makes a greater explosion.

It is easily comprehended, that in the pistols described above, there cannot be introduced a mixture of inflammable and common air in any required proportion, much less can there be introduced a mixture of inflammable and oxygen air. In order to avoid this great inconvenience, Dr. Ingenhousz contrived another pistol, into which any required mixture of elastic fluids may be introduced. This pistol, and its separate parts, are exhibited in fig. the 21st, plate II. A *a* is the barrel of the pistol. B is the box or chamber for the elastic fluids. *b* the place where the barrel is screwed to the box. C the handle of the pistol. D is the wire or handle of the piston LK, the lower part of which, *h h*, is made square, in order to prevent its turning round. E is a hole on the side of the box, which is occasionally shut, by screwing the small nut *e* in it. F is a piece of brass with a female screw, which is fixed to the wooden handle by means of three strong screws, and to which the lower part *f* of the box is screwed. G is a piece of ivory fixed to the piston with a conical ivory termination L, which fits the conical end of the box. M. is the perforation in the wooden handle, through which the brass wire D passes. N is a small brass ball at the extremity of a wire, which passes through the canal R in the ivory cone. O is another piece of wire which passes through another hole, and touches the brass under the ivory piece. The wires are both fixed into the holes by means of the cement mentioned above. P is the small interval between the extremities of the two wires, through which the electric spark passes, when given by means of a charged electrical bottle to the ball N.

When the parts of this pistol are put together, as shewn by ABCD, the piston is pulled back, so as its part K may be at F, and the box is filled with inflammable and respirable air; the electric spark given to the small brass ball, as mentioned above, will inflame the gas, and its force will push a bullet, which is previously fixed into the barrel just where this is screwed to the box. But in order to charge the pistol with a mixture of inflammable and common air, or inflammable and oxygen air, in mens * from the oxygenated marine acid, or from the kindling influence of

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any required proportion, the piston must be pushed towards the conical part of the pistol, then unscrewing the barrel, the aperture of the pistol is applied to the neck of the bladder containing the mixture of inflammable and common or oxygen air, and drawing back the piston, that mixture of elastic fluid is introduced into the chamber or box of the pistol. This done, the bladder is detached from the extremity of the pistol, and at the same time a small leaden bullet, wrapped up in soft leather, is applied to the said aperture, and the barrel is screwed over it; thus the pistol is *charged*, and is now ready to be fired. Vide CAVALLO ON THE DIFFERENT FACTITIOUS AIRS.

* The *bitumens* generally taken notice of by writers on Natural History are, with respect to their consistence, either as fluid as oil, or as thick and tenacious as tar, or quite solid. The fluid bitumens are two, naptha, and petroleum, or rock-oil. These are oils which differ from each other in colour and consistence, and some other properties; the naptha is pale, light, and very inflammable; the petroleum is yellow, brown, or blackish, heavier and less inflammable than naptha: its difference from the naptha is attributed to its containing a greater quantity of acid in its composition. Both these oils are found in many parts of the globe, either floating on spring water, or dripping from the crevices of rocks. Mineral pitch is a bitumen which differs from petroleum in being thicker, heavier, and more glutinous; it was formerly found in the environs of Babylon, and constituted, according to Vitruvius, when mixed with lime, the cement which was used in building the walls of that city. At present it is met with in several parts of Europe, and in America, where it drips from rocks, and is called by us Barbadoes tar: it has a very offensive smell, and great tenacity, and is called by the inhabitants of Auvergne, in France, where it exudes from the earth, and sticks to the feet, devils dung. The asphaltum, or Jews pitch, is a bitumen much resembling mineral pitch; it is thrown up in a liquid form from the bottom of the lake where Sodom and Gomorrah stood, otherwise called the Dead Sea, or the lake Asphaltes, from a Greek word denoting a bitumen. This lake in the time of Esdras yielded bitumen—"*remember what I did to Sodom and Gomorrah, whose land lieth in clods of pitch.*" The bitumen floating upon the surface of the salt water, is condensed by the heat of the sun into a solid form, and is gathered by the Arabs on the shore where it is thrown. It is said to be the same substance which the Egyptians used in embalming their mummies, and it was called by them mummia mineralis. This bitumen has been found in many places of Asia and Europe, as well as on the shores of the Dead Sea; all that we meet with in the shops, is either an artificial composition, or an European asphaltum, the eastern ones being seldom brought into Europe, but used by the natives either as pitch for their ships, or as an ingredient in varnishing, or dying wool.

There is a very curious experiment which illustrates the relation which these four bitumens bear to each other. The most transparent oil of turpentine, resembling naptha, may be changed into an oil resembling petroleum, by mixing it with a small portion of the acid of vitriol; with a larger proportion of the acid, the mixture becomes black and tenacious, like Barbadoes tar; and the proportions of the ingredients may be so adjusted, that the mixture will acquire a solid consistence, like asphaltum. This experiment teaches us to conclude that naptha, petroleum, Barbadoes tar, and asphaltum, differ chiefly from each other, with respect to the quantity of acid which enters into their composition; and the substances procured by distilling pitcoal, or resinous vegetables, may furnish no improbable conjecture concerning the origin of these bitumens.

Let us suppose then a subterraneous fire to be situated in or near a stratum of pitcoal, of turf, of fossil wood, or of any other such bituminous matter; it is manifest that the inflammable air, and the different kinds of oils, which were collected by distilling small portions of these substances, would be elevated by the heat into the crevices of the superincumbent strata; the light and pale oil would be a sort of naptha, or petroleum, the black and tenacious oil would be a Barbadoes tar, and this might be so dried by the heat as to become an asphaltum. The oils not being miscible with water, would be found floating upon its surface, as it issued out of the bowels of the earth, and being very inflammable, might constitute burning wells, such as have been met with near Wigan, at Brosely, and in many other places: or where the oil did not meet with water, or was too heavy to float on it, we may conceive that it would impregnate the porous strata of several kinds of stones and earth. It has been the electric fluid,* when an explosion takes place, and if the vent be sufficient from the open crater of the agitated volcano, an earthquake is avoided,

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observed in another place, that they formerly obtained a sort of tar from a stone at Broseley; and the stratum which is called shale in Derbyshire, is so strongly impregnated with oil, that it will burn of itself, when set on fire: the workmen in digging through the black stone, which is incumbent on the shale, sometimes meet with cavities containing a thick black oil, which has oozed out of the surrounding stone. One of the greatest soughs, or subterraneous passages, which has, perhaps, ever been formed in great Britain, is that which is called Hell-car sough, in Derbyshire; this sough is driven through a stratum of shale, and the workmen are much troubled with *inflammable air*, which generally breaks into the sough, through the same crannies which give passage to little streams of water; they secure themselves from the air, by keeping great fans constantly in motion; for the inflammable air, being lighter than common air, floats near the roof of the sough, and being drawn down from thence, and mixed with the common air by the motion of the fans, it is circulated in the sough without danger. I am sensible that inflammable air may be produced by various other ways, as well as by the application of heat, to bituminous strata; but as bitumens do yield this air by distillation, it is probable enough, that such as is met with in bituminous strata, may sometimes, at least, be referred to the action of fire, situated, perhaps, at too great a distance from the surface of the earth to produce any other sensible effect. Vide the Bishop of Llandaff's very amusing and instructive CHEMICAL ESSAYS.

In the Duchy of Modena in Italy, there is a remarkable rock, which confirms very much the notion of oils and pitchy substances being separated from bitumens by a kind of subterraneous distillation. The inhabitants of the district, by piercing the sides of this rock, at different distances from its summit, obtain oil of different natures, thickening and growing heavier and deeper coloured, as the canals through which they flow approach to the surface of the earth; at the distance of a few feet below the surface of the earth, they find a very thick oil, which in digging deeper becomes soft as butter, and at still a greater depth, it is found to be as solid as pitch.

Near Derbens, on the Caspian Sea, there are springs of naptha, which Kempfer visited about a century ago, and of which he has left a description.

There is a place known by the name of the Perpetual Fire, where the fire burns without ceasing. The Indians do not attribute the origin of this inextinguishable fire to naptha; but they maintain that God has confined the Devil in this place, to deliver man from him. They go in pilgrimage thither, and make their prayers to God that he will not suffer this enemy of mankind to escape.

The earth impregnated with naptha is calcareous, and effervesces with acids; it takes fire by the contact of any ignited body whatever.

This perpetual fire is of great use to the inhabitants of Baku. They pare off the surface of this burning soil, upon which they make a heap of limestones, and cover it with the earth pared off; and in two or three days the lime is made.

The inhabitants of the village of Frogann repair to this place to cook their provisions.

The Indians assemble from all parts to adore the Eternal Being in this place. Several temples were built, one of which is still in existence. Near the altar there is a tube inserted in the earth, two or three feet in length; out of which issues a blue flame, mixed with red. The Indians prostrate themselves before this tube, and put themselves into attitudes which are exceedingly strange and painful.

Concerning the accension of different bodies by the mineral acids, vide note * page (102).

* The observations made by Sir William Hamilton on the last tremendous eruption of mount Vesuvius, shew how much the *electric fluid* is concerned in volcanic explosions.

“The black smoke of ashes, says this author, issuing continually from so many new mouths or craters, formed an enormous dense body of clouds over the whole mountain, and which began to give signs of being replete with the electric fluid, by exhibiting flashes of that sort of zig-zag lightning, which, in the volcanic language of this country, is called *ferilli*, and which is the constant attendant on volcanic eruptions.

During thirty years that I have resided at Naples, and in which space of time I have been witness to many eruptions of Vesuvius, of one sort or other, I never saw the gigantic clouds above-mentioned and we have then only those natural fireworks, which as much surpass the imitated, as heaven is higher than the earth, but which impart a dreadful fear to the astonished inhabitants of those countries, where such tremendous scenes are carried on.

Hence in opposition to Dr. Darwin, but with a becoming deference, we conclude, that as in our frames a continued combustion is going on productive of *animal heat,** the sine qua non of life, and sensation, so there is a

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so replete with the electric fire, except in the two great eruptions of 1767 and 1779. The electric fire, in the year 1779, that played constantly within the enormous black cloud over the crater of Vesuvius, and seldom quitted it, was exactly similar to that which is produced, on a very small scale, by the conductor of an electrical machine communicating with an insulated plate of glass, thinly spread over with metallic filings, &c. when the electric matter continues to play over it in *zig-zag* lines, without quitting it. I was not sensible of any noise attending that operation in 1779, whereas the discharge of the electrical matter from the volcanic clouds during this eruption, and particularly the second and third days, caused explosions like those of the loudest thunder, and, indeed, the storms raised, evidently by the sole power of the volcano, resembled, in every respect, all other thunder-storms, the lightning falling and destroying every thing in its course.

Out of these gigantic and volcanic clouds, beside the lightning, both during this eruption and that of 1779, I have, with many others, seen balls of fire issue, and some of a considerable magnitude, which, bursting in the air, produced nearly the same effect as that from the air-balloons in fire-works, the electric fire which came out having the appearance of the serpents with which those firework balloons are often filled. The day on which Naples was in the greatest danger from the volcanic clouds, two small balls of fire, joined together by a small link like a chain-shot, fell close to my casino at Posilipo; they separated, and one fell in the vineyard above the house, and the other in the sea.

The Abbé Tata, in his printed account of this eruption, mentions an enormous ball of this kind which flew out of the crater of Vesuvius while he was standing on the edge of it, and which burst in the air at some distance from the mountain; soon after which he heard a noise like the fall of a number of stones, or of a heavy shower of hail."

After the eruption had ceased, when Sir William Hamilton ascended the mountain, he thus writes, "While we were on the mountain, two whirlwinds, exactly like those that form waterspouts at sea, made their appearance; and one of them, which was very near us, made a strange rushing noise, and having taken up a great quantity of the fine ashes, formed them into an elevated spiral column, which, with a whirling motion, and great rapidity, was carried toward the mountain of Somma, where it broke, and was dispersed. As these were evident signs of an abundance of electricity in the air at this time, I have no doubt of this having been also an electrical operation."

* The ingenious Dr. Crawford appears to have been the first who attempted to ascertain by direct experiments the cause of ANIMAL HEAT as dependant upon the air. In an elaborate work he maintains, that the blood, which is returned to the lungs, is highly charged with *phlogiston,*—that the air having a greater affinity for *phlogiston* than the blood, attracts to itself *that principle,* and having in consequence a less *capacity* for heat than before, it parts with a portion of its heat,—and as the *capacity* of blood for heat is at the same time increased by the separation of the *phlogiston,* the *heat,* detached from the air, is fixed in a quiescent or latent state in the blood:—and that the blood in the course of the circulations absorbing *phlogiston,* and thereby having its *capacity* for *heat* diminished, part of it (in proportion to the quantity of *phlogiston* absorbed) breaks out in the form of sensible or moving heat, and hence the cause of ANIMAL HEAT.

It required a very strong philosophic conviction in any one to depart from a proposition at that time so generally received. But having made many experiments, when enquiring into this subject, Dr.

continued fermentation going on in the bowels of the earth, liberating fire

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was confident, that the OXYGEN AIR which WAS ABSORBED BY THE BLOOD (as is proved in Sect. VI.) was the true source of ANIMAL HEAT. Struck with the important discovery, he proposed it as the subject of his *thesis* at Cambridge. The professors of physic and of chemistry were pleased at the *novelty* of the opinion, and very politely consented to his disputation on that question, so that Dr. THORNTON first maintained at Cambridge, previous to his receiving his degree in physic in that university, in opposition to the opinion of Dr. Crawford, "that the *venal* blood in the lungs absorbs from "air not *fire,* but *oxygen,* in combination with *the matter of heat* (OXYGEN AIR), and that in the "circuit of the blood through the body, the *oxygen,* meeting with some superior attraction, is divorced "from its *caloric,* (the matter of heat), which becoming disengaged *just as an acid discovers its sen-"sible properties, its alkaline basis being withdrawn from it),* so did it assume its well known "*active* character; and as *uncombined fire* ever tends to form an equilibrium, or equal temperature "with the substances around, by pervading the body, it became the source of VITAL or ANIMAL "HEAT."

Animal heat, therefore, appears to be a *gentle combustion* :—and *an animal* in many respects may be compared to a *burning lamp*; the HEAT produced in both cases arising from the *same cause.*

If AN ANIMAL be placed in *an exhausted receiver* of an air pump it quickly expires; in similar circumstances A BURNING LAMP goes out. If AN ANIMAL be not supplied with *fresh air* it dies, and its *heat* is extinguished; so it is with the LAMP. The air breathed by ANIMALS is *diminished in quantity*; so it is by the burning of THE LAMP. A *certain quantity* of air supports AN ANIMAL for a *certain time,* but no longer; so it will keep up the FLAME OF THE LAMP, for a *certain* time only. The air in which a LAMP has burnt out *destroys* ANIMAL *life*; so the air that THE ANIMAL hath breathed, *puts out* THE LAMP. Fixed, azotic, and inflammable airs, *destroy* ANIMALS; so likewise do they *extinguish* THE LAMP.

A LIVING ANIMAL and a BURNING LAMP, therefore, exactly agree in requiring the *same kind of air* to support them, and in producing *the same effects* upon the air, to which they are exposed.

But they do not resemble each other only in *producing* HEAT, *and requiring the same kind* of AIR: for if AN ANIMAL hath not *fresh supplies* of FOOD, as well as AIR, after a *certain time* it dies, and becomes cold; just in the same manner as THE LAMP dies out, if not *duly supplied* with OIL.

Since then *that part* of the air destroyed by RESPIRATION is the *same* as *that* destroyed by COMBUSTION; and since the *ultimate effect* is the *same* in both operations, that is, THE PRODUCTION OF HEAT, is it not reasonable to think, that the FOOD affords to the ANIMAL *principles alike attractive of* OXYGEN, *and disengaging* HEAT, as the OIL affords to THE LAMP? For since *the effects* are the same, *the cause* must be so too. OIL, therefore, *affords the principle attractive of* OXYGEN to THE LAMP: and, consequently, THE FOOD of animals *supports the generation of heat,* by *supplying to the animal body those principles which are attractive of* OXYGEN, *the base of vital air.*

The *chemical analysis* of such substances as are to support animal life confirms this opinion; for no substance affords proper nourishment, which contains not principles that readily combine with OXYGEN; and the instantaneous support, and refreshment, perceived by those, who are much exhausted, upon taking into the stomach certain inflammable substances, as diluted spirits, &c. depend upon the same principle. *Very different matters,* therefore, will support ANIMAL LIFE, if they contain principles, separable by the animal process, that have an affinity with *oxygen.*

To prove that *animal heat* arises from the *decomposition* of VITAL AIR by those substances which attract *oxygen,* we have the following very striking fact.

Dr. Beddoes, the justly celebrated professor of chemistry at Oxford, respired at times for seven weeks air of a much higher than the ordinary standard, and commonly such as contained almost equal parts of oxygen and common air. He relates, in his letter to Dr. Darwin, "that he felt that agreeable "*glow,* and lightness of the chest, which has been described by Dr. Priestley and others. In no long "time," he says, "I observed in myself a remarkable power of sustaining *cold.* Except one or two "evenings I never once experienced the sensation of *chilliness,* though cold easterly winds prevailed, "during great part of the time I inspired the *super-oxygenated air.* I was not only able," he adds, from its various component parts, obeying the laws of attraction,* and that

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" to reduce my bed-clothes to a single blanket and coverlid, but slept without inconvenience in a large " bed-chamber, looking to the north-east, with the window open all night, and with the door and " windows of an adjacent sitting room also open.—My appetite was keen, and I eat *one third* or *one " fourth more than before,* without feeling the stomach loaded."

Animal heat, therefore, proceeds from the chemical union of certain parts of our food and oxygen, modified, and combined, by the proper exercise of the natural animal functions, disengaging caloric. Vide THE PHILOSOPHY OF MEDICINE: or, MEDICAL EXTRACTS on the NATURE OF HEALTH AND DISEASE, including the LAWS OF THE ANIMAL ŒCONOMY and the DOCTRINES OF PNEUMATIC MEDICINE.

* The SUPREME BEING has given a force of mutual attraction to the parts of matter; a principle which is alone sufficient to produce that arrangement which the bodies of this universe present to our observation. As a very natural consequence of this primitive law, it follows that the elements of bodies must have been urged towards each other; that masses must have been formed by their re-union; and that solid and compact bodies must have insensibly been constituted; towards which, as towards a centre, the less heavy and less compact bodies must gravitate.

This law of attraction, which the chemists call Affinity, tends continually to bring principles together which are disunited, and retains with more or less energy those which are already in combination; so that it is impossible to produce any change in nature, without interrupting or modifying this attractive power.

Affinity is exercised either between principles of the same nature, or between principles of a different nature.

We may, therefore, distinguish two kinds of affinity, with respect to the nature of bodies.

1. THE AFFINITY OF AGGREGATION, *or that which exists between two principles of the same nature.*

2. The AFFINITY OF COMPOSITION, *or that which retains two or more principles of different natures in a state of combination.*

OF THE AFFINITY OF AGGREGATION.

Two drops of water which unite together into one, form an aggregate, of which each drop is known by the name of an integrant part.

An *aggregate* differs from a *heap*; because the integrant parts of this last have no perceptible adhesion to each other; as, for example, a heap of barley, of sand, &c.

An aggregate, and a heap, differ from a *mixture*; because the constituent parts of this last are of a different nature; as, for example, in gunpowder.

The affinity of aggregation is stronger the nearer the integrant parts approach to each other; so that every thing which tends to separate or remove these integrant parts from each other, diminishes their affinity, and weakens their force of cohesion.

Heat produces this effect upon most known bodies: hence it is that melted metals have no consistence. The caloric, or matter of heat, by combining with bodies, almost always produces an effect opposite to the force of attraction; and we might consider ourselves as authorised to affirm that it is a principle of repulsion, if sound chemistry had not proved that it produces this effect only by its endeavour to combine the bodies, and thereby necessarily diminishing their force of aggregation, as all other chemical agents do. Besides which, the extreme levity of caloric produces the effect that, when it is combined with any given body, it continually tends to elevate it, and to overcome that force which retains it, and precipitates it towards the earth.

The mechanical operations of pounding, of hammering, or of cutting, likewise diminish the affinity of aggregation. They remove the integrant parts to a distance from each other; and this new disposition, by presenting a less degree of adhesion, and a larger surface, facilitates the immediate action, same law which keeps all the planets, and the whole host of heaven in their respective places, and which must create in us more astonishment, that

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and augments the energy, of chemical agents. It is for this purpose that bodies are divided when they are to be analysed, and that the effect of re-agents is facilitated by the action of heat.

The mechanical division of bodies is more difficult, the stronger their aggregation.

Aggregates exist under different states; they are solid, liquid, or aëriform.

OF THE AFFINITY OF COMPOSITION.

Bodies of different kinds exert a tendency or attraction upon each other, which is more or less strong; and it is by virtue of this force that all the changes of composition or decomposition observed amongst them, are effected.

The affinity of composition exhibits invariable laws in all the phenomena it causes. We may state these laws as general principles; to which may be referred all the effects presented to our observation by the action of bodies upon each other.

Law I. *The affinity of composition acts only between the constituent parts of bodies.*

The general law of attraction is exerted upon the masses; and in this respect it differs from the law of affinities, which does not perceptibly act but on the elementary particles of bodies. Two bodies placed near each other do not unite; but, if they be divided and mixed, a combination may arise. We have examples of this when the muriate of soda, or common salt, is triturated with litharge; the muriate of ammoniac, or common sal ammoniac, with lime, &c. And it may be asserted, that the energy of the affinity of composition is almost always proportioned to the degree of the division of bodies.

Law II. *The affinity of composition is in the inverse ratio of the affinity of aggregation.*

It is so much the more difficult to decompose a body, as its constituent principles are united or retained by a greater force. Gases, and especially vapours, continually tend to combination, because their aggregation is weak: and nature, which is constantly renewing the productions of this universe, never combines solid with solid; but, reducing every thing into the form of gas, by this means breaks the impediments of aggregation; and these gases uniting together, form solids in their turn.

Hence, no doubt, it arises, that the affinity of composition is so much the more strong as bodies approach nearer to the elementary state; and we shall observe, on this subject, that this law of nature is founded in great wisdom: for if the force of affinity of composition did not increase in proportion as bodies were brought to this degree of simplicity; if bodies did not assume a decided tendency to unite and combine, in proportion as they approach to their primitive or elementary state; the mass of elements would continually increase by these successive and uninterrupted decompositions; and we should insensibly return again to that chaos or confusion of principles, which is supposed to have been the original state of the globe.

The necessity of this state of division, which is so proper to increase the force of affinity, has caused it to be admitted as an incontestable principle, that the difficulty of composition does not take place, unless one of the bodies be in the fluid state: "*corpora non agunt nisi sint fluida.*" But it seems to me that extreme division might be substituted instead of dissolution; for both these operations tend only to attenuate bodies, without altering their nature. It is by virtue of this division, which is equivalent to the dissolution, that the decomposition of muriate of soda is effected by trituration with minium, as well as the union of cold and dry alkali with antimony, and the disengagement of volatile alkali by the simple mixture of sal ammoniac with lime.

Law III. *The compound which results from the combination of two bodies, possesses properties totally different from those of its constituent principles.*

Some chemists have affirmed, that the properties of compounds were intermediate between those of their constituent parts. But this term "intermediate" has no meaning in the present case; for what intermediate qualities can exist between sour and sweet, or between water and fire?

If we attend ever so little to the phenomena which are exhibited to us by bodies in their compoif a continued interference of omnipotent power was constantly being ex-

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sition, we shall perceive that their form, their taste, and their consistence, are changed in combination; and we cannot establish any rule to indicate, *á priori*, all the changes which may arise, and the nature and properties of the body which shall be formed.

Law IV. *Every individual substance has its peculiar affinities with the various substances presented to it.*

If all bodies had the same degree of affinity with each other, no change could take place amongst them; we should not be able to displace any principle by presenting one body to another. Nature has therefore wisely varied the affinities, and appointed to each body its relation with all those that can be presented to it.

It is in consequence of this difference in the affinities, that all chemical decompositions are effected: all the operations of nature and art are founded upon it. It is therefore of importance to be well acquainted with all the phenomena and circumstances which this law of decomposition can present to us.

The affinity of composition has received different names, according to its effects; it is divided into simple affinity, double affinity, the affinity of an intermedium, reciprocal affinity, &c.

1. Two principles united together, and separated by means of a third, afford an example of simple affinity; it consists in the displacing of one principle by the addition of a third. Bergman has given it the name of *Elective Attraction.*

The body which is disengaged, or displaced, is known by the name of the *Precipitate.* An alkali precipitates metals from their solutions; the sulphuric acid precipitates the muriatic, the nitric, &c.

The precipitate is not always formed by the disengaged substance. Sometimes the new compound itself is precipitated; as, for example, when I pour the sulphuric or vitriolic acid on a solution of muriate of lime. Sometimes the disengaged body and the new compound are precipitated together; as, for example, when the sulphate of magnesia or Epsom salt is dissolved in water, and precipitated by means of lime water.

2. It often happens that the compound of two principles cannot be destroyed either by a third or a fourth body separately applied; but if these two bodies be united, and placed in contact with the same compound, a decomposition or change of principles will then take place. This phenomenon constitutes *double affinity.* An example will render this proposition more clear and precise. The sulphate of pot-ash or vitriolated tartar is not completely decomposed by the nitric acid or by lime, when either of these principles are separately presented; but, if the nitric acid be combined with lime, this nitrate of lime will decompose the sulphate of pot-ash. In this last case the affinity of the sulphuric acid with the alkali is weakened by its affinity to the lime. This acid, therefore, is subject to two attractions; the one which retains it to the alkali, and the other which attracts it towards the lime: Mr. Kirwan has named the first the *Quiescent Affinity,* and the other the *Divellent Affinity.* The same may be said respecting the affinities of the alkali; it is retained to the sulphuric acid by a superior force, but is nevertheless attracted by the nitric acid. Let us suppose, now, that the sulphuric acid adheres to the alkali with a force as 8, and to the lime by a force expressed by the number 6; that the nitric acid adheres to the lime by a force as 4, and tends to unite with the alkali by a force as 7. It may then be perceived that the nitric acid and the lime, separately applied to the sulphate of pot-ash, would not produce any change: but if they be presented in a state of combination, then the sulphuric acid is attracted on the one hand by 6, and retained by 8; it has therefore an effective attraction to the alkali as 2. On the other hand, the nitric acid is attracted by a force as 7, and retained by a force as 4; it therefore retains a tendency to unite with the alkali, which is denoted by the number 3; and consequently it ought to displace the sulphuric acid, which is retained only by a force as 2.

3. There are cases in which two bodies, having no perceptible affinity to each other, obtain a disposition to unite by the intervention of a third; and this is called the affinity of an intermedium. An alkali is the intermedium of union between oil and water; hence the theory of lixiviums, of washing, &c. &c.

If the affinities of bodies were well known, we might foretel the results of all operations: but it erted;[*] and as fevers, or even actual combustion[†], have arisen with us from a certain peculiar state, or combination of the elements, which in moderation, create

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is obvious how difficult it must be to acquire this extensive knowledge of nature; more especially since modern discoveries have exhibited to us an infinity of modifications in our processes, and have shewn that results may vary with such facility, that even the absence or presence of light will render them very different.

As long as chemistry was confined to the knowledge of a few substances, and was busied only in attending to a certain number of facts, it was possible to draw up tables of affinity, and to exhibit the result of our knowledge in one and the same table. But all the principles upon which these tables have been constructed, have received modifications; the number of principles has increased; and we find ourselves under the necessity of labouring upon new ground. A sketch of this great work may be seen in the Essay on Affinities of the celebrated Bergman, and in the article Affinity in the *Encyclopéde Methodique*.

LAW V. *When two or more bodies unite by the affinity of composition, their temperature changes.*

This phenomenon cannot be explained but by considering the fluid of heat as a constituent principle of bodies, unequally distributed among them; so that, when any change is produced in bodies, this fluid is displaced in its turn, which necessarily produces a change of temperature.

[*] GOD governs by *second causes,* says the great Newton, and it certainly argues in that BEING most power to endow matter with such properties as may serve the intentions of the CREATOR, without HIS being obliged every moment to be adjusting its component parts, and animating the wheels of that stupendous machine. Equally is Nature dependant upon his will:—for if HE ceased his energy, matter would instantly lose its power. A child keeps on beating his top, and it spins round. GOD but *wills,* and the great globe moves round its own axis, and describes its appointed circuit, until matter loses the power delegated to it by the same *will,* which first implanted it.

[†] At first, the food taken into the stomach retaining its peculiar qualities, *irritates* the inner coat of that organ, and occasions a contraction of its two orifices. The food, thus confined, then undergoes a constant agitation by means of the abdominal muscles, and of the diaphragm, and by the motion of the fibres of the stomach itself. By these movements every part of the food is exposed to the action of a fluid secreted in the stomach, called *the gastric juice,* which (as water dissolves sugar) gradually dissolves and attenuates the food (as presently will be proved), and prepares it for its passage into, and farther change in, the intestines.

Our aliment is therefore broken down in the stomach into its constituent principles, and these comminuted parts then enter and pass along the capillaries of the intestines, which are incapable of admitting any substance, unless in an highly attenuated or *aerial* form.

The anatomical lecturer at Pisa, in the year 1597, happening to hold a lighted candle near the subject he was dissecting, on a sudden the vapours that issued from the stomach and intestines were set on fire. In the same year Dr. Ruisch was dissecting a woman, and had no sooner opened the stomach, than there issued out a yellow greenish flame, supposed to have arisen from the vapours, which were kindled by a student's holding a lighted candle near him.

Dr. Vulpare, the anatomical professor at Bologna, affirms that any one may see, issuing from the stomach of an animal, a vapour that *burns like spirits of wine,* if the upper and lower orifices are bound fast with a tight thread. The stomach thus tied up, must be cut immediately under the upper ligature, the contents of the stomach being first pressed with both hands, so as to pass to one side. A candle being held about half an inch from the aperture, a flame will be observed immediately to issue from the stomach.

Bartholine relates the case of a person, who having drank much brandy for a wager, died, after an eruption of a flame of fire had issued from his mouth. *The inflammable woman of Coventry,* as described by Mr. Wilmer, appears also to have reduced herself by dram-drinking to such a state as to be capable of being set on fire, and burn like any very combustible matter; *so eager,* says the learned Dr. Beddoes, *were the principles of which she was composed to combine with oxygen.*

the proper vital flame, so is terrestrial heat, as are also volcanoes and earthquakes to be considered by the philosopher as arising from a like source.

In like manner the countess *Cornelia Bandi*, near Cesena in Romagna, in 1731, in the sixty-second year of her age, was found in the middle of her bedchamber reduced to ashes. These ashes were light, and left in the hand a greasy and sticking moisture. The floor was smeared with a gross unpleasant moisture, and the walls and furniture were covered with a moist soot.

An instance of the same kind occurred at Christ-Church in Hampshire, June 26, 1613; one John Hitchell, a carpenter of that parish, a great drunkard, having ended his day's work, came home and went to bed. His wife found him dead before morning at her side. He felt so extremely hot, that it was impossible to touch him. *He lay burning for three days*; nor was there any appearance of flame outwardly, but only a smoke or mist ascending from his carcase till it was consumed.

On the night of the 16th of March 1802, in one of the towns of the State of Massachusetts, the body of an elderly woman evaporated and disappeared from some internal and unknown cause, in the duration of about one hour and an half. Part of the family had gone to bed, and the rest were abroad. The old woman remained awake to take care of the house. By and by one of the grand-children came home, and discovered something near the hearth to be on fire. An alarm was made, a light brought, and means taken to extinguish it. While these things were doing, some singular appearances were observed on the hearth and the contiguous floor. There was a sort of greasy soot and ashes, with remains of a human body, and an unusual smell in the room. All the clothes were consumed; and the grandmother was missing. It was at first supposed she had, in attempting to light her pipe of tobacco, fallen into the fire, and been burned to death. But on considering how small the fire was, and that so total a consumption could scarcely have happened if there had been ten times as much, there is more reason to conclude that this is another case of that spontaneous decomposition of the human body, of which there are several instances on record.

These curious instances of *quick combustion* carried on in the body, if I may be allowed to continue the expression, are adduced only as exceptions to Dr. Thornton's general rule, which he was the first to establish, " that within the body there is *always* carried on a *gentle combustion*, productive of *the vital flame*." Extracted from the PHILOSOPHY OF MEDICINE, vol. ii. p. 21.

Fevers in like manner arise from a new combination of elementary matter, liberating heat, and thus destroying life. In this way several poisons produce their almost instantaneous effects, and hence to render meat tender, animals in the West Indies are killed by stabbing them with a needle infected with poison. A sufficient putrefaction, or tendering the meat, is thus instantaneously incurred, and the poison by entering into a new combination wholly loses its life-destroying power, and is therefore rendered innoxious. Vide the PHILOSOPHY OF MEDICINE, Vol. IV. from page 117 to page 152.

To vindicate GOD as to the introduction of *evil* into *this nether world*, various have been the attempts of prying philosophers. That *evils* were *designed* to exist here is *undoubted*, although some make them only *accidental*. Considering this earth as a temporary abode for transient beings, whose life compared with eternity is as a grain of sand to the whole mass of this globe, or all the myriads of globes revolving round their respective suns, *nothing can be said to be an evil*, and as each respective world is probably only *a scene* of the *drama of the universe* for the *contemplation* of *us*, and of *other superior beings*; and as *our's* exhibits both the contrasts of *tragedy* and of *comedy* blended together, let us not, however, even utter a faint murmur at our *seven ages*, considering this only as a PREPARATION in a *subordinary*, towards a *higher part*, which we shall have to act *next* as *angels*, or as *demons*, in a *higher* or *lower* world, *comfortable* or *inhospitable*, as *best appointed* for created beings progressive by their free-will in *virtues* or in *vices*, and so rightly stationed on *solid* or *unsound earth*, that is, either for *reward* or *punishment*, or, using the true interpretation of the scripture phrase, chastisement or correction.

SECT. XIX.

XII. ON ELECTRICITY AS PROMOTING GERMINATION.

> NYMPHS! your fine hands ethereal floods amass
> From the warm cushion, and the whirling glass;
> Beard the bright cylinder with golden wire,
> And circumfuse the gravitating fire.
> Bright from each point cerulean lustres gleam,
> Or, shoot in air the scintillating stream.
>
> DARWIN.

HAVING amply considered the source and influence of heat on the seed, we are next led to contemplate the power of the *electric fluid* in promoting the progress of germination.

It must appear surprising to every searcher after truth, that electricity, which is now allowed to be one of the principal agents employed in producing the phænomena of nature, should have remained so long in obscurity; for, comparatively speaking, its existence was not known to the ancients. They were not, indeed, altogether ignorant of the peculiar properties of those bodies that we now term *electrics*;* nevertheless their knowledge was circumscribed, being confined to the observation only of those phænomena which nature presented to their senses, in the ordinary course of her operations; hence near two thousand years elapsed, before any addition was made to the little which was known to Theophrastus, and this branch of natural history remained uncultivated, till the happy period arrived, when the philosopher was emancipated from the chains of hypothetic reasoning, and the uncertainties of vague conjecture.

The existence of this subtle, and in most cases invisible power, was then traced, and many of its properties developed; its agency was discovered to be universal, and its extent unlimited.

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* Thus the ancients knew the electric power of amber, and of sulphur, upon friction, and hence the derivation of the term of this science from ελεκτρον, which signifies amber in Greek.

It must be evident indeed, even to a superficial observer, that electricity is no trivial or confined subject; because there is no body in nature that is not acted upon in a greater or less degree by this wonderful agent.

The importance of the electric fluid in the system of the world, is confirmed by a consideration of those phænomena in which it is concerned, and which take place without the concurrent operation of man.

Thus several fishes possess the property of giving the electric shock. The torpedo, and one or more species of eels, from Surinam, if touched by the hand, a metal rod, or any other conductor, give a considerable shock to the arm, but may be safely touched by a bit of sealing-wax. The shock depends on the will of the fish, and is transmitted to a great distance; so that if persons in a ship happen to dip their fingers or feet in the sea, where the fish is swimming at the distance of fifteen feet, they will be affected therewith.

Otto Guericke, burgomaster of Madgeburgh, first made a globe of *sulphur*, and by whirling it about in a wooden frame, and rubbing it at the same time with his hand, he performed various electrical experiments. He added to the stock of knowledge the discovery, that a body once attracted by an excited electric was repelled by it, and not attracted again till it had touched some other body. Thus he was able to keep a feather suspended in the air over his globe of sulphur; but he observed, if he drove it near a linen thread, or the flame of a candle, it instantly recovered its propensity (if I may use the expression) for approaching the globe again. "The hissing noise," and the "gleam of light which his globe afforded, both attracted his notice."

These circumstances were, however, afterwards more accurately remarked by Dr. Wall, who, by rubbing *amber* upon a woollen substance in the dark, found also that light was produced in considerable quantities, accompanied with a crackling noise; and what "is still more extraordinary," he adds, "this light and crackling seems, in some degree, to represent thunder and lightning."

That the electric fluid and lightning were the same was, however, first *demonstrated* by the great Dr. Franklin. He early observed the power that points possess in drawing off the electricity of bodies, and thence inferred that a pointed metallic bar, if insulated at a considerable height in the air, would become electrical by communication from the clouds during a thunder-storm.

The first apparatus that exhibited this ethereal body was that of Mons. Dalibard, at Morly-la-ville, about six leagues from Paris.

It consists of a bar of the length of forty feet, and was electrified on the 10th of May 1752, for the space of an hour, during which time it emitted sparks, of two inches in length, which crackled like sparks issuing from an electrified conductor.

Dr. Franklin, about a month after this, devised a more certain method of ascertaining this curious hypothesis.

Instead of a rod, it occurred to him that he could have a readier and better access to the regions of thunder by means of a common kite.

He accordingly adjusted a silk handkerchief to two sticks placed crosswise. At the approach of the first storm he repaired to a field where there was an out-house conveniently situated for his experiment; and in order to obviate the ridicule that but too commonly accompanies unsuccessful attempts for the promotion of the sciences, he took care to communicate his intentions to no one but his son, whose assistance was absolutely necessary upon this occasion.

Having launched his kite into the air, with a pointed wire fixed to the end of it, he soon succeeded so far as to elevate it to the proper height. It was a long time before he discovered the least appearances of electricity. A dense black cloud had already passed over his head without any effect whatever, and he began actually to despair of success, when happening to look with more than ordinary attention, he at length perceived a lambent flame to stream along the hempen cord. The lightning (for it was actually such!) descended along the string, and was received by an iron key tied to the extremity of it, while this was connected with his hand by means of a piece of silken cord.

What must have been his joy, when presenting his knuckles to the key at the end of the hempen string, he felt an electric shock, and found out that his discovery was complete!

He now clearly perceived the electric sparks; more followed in succession, and when the string became humid by means of the rain, it conducted the electric fluid with still greater freedom, so that it would stream out plentifully from the key, at the approach of a person's finger. At this key he charged phials, and from electric fire thus obtained, kindled spirits, and performed all other electrical experiments which are usually exhibited by means of an excited globe or tube.

This memorable and indeed wonderful experiment took place in June 1752.

Mr. Baldwin raised an electrical kite in July, 1771, during the approach of a severe thunder storm, and observed himself to be surrounded by a rare medium of fire, which, as the cloud rose nearer the zenith, and the kite got higher, continued to extend itself with some gentle faint flashes. Mr. Baldwin felt no other effect than a general weakness in his joints and limbs, and a kind of listless feeling; all which, he observes, might possibly be the effect of surprise, though it was sufficient to discourage him from persisting in any farther attempt at that time. He therefore drew in the kite, and retired to a shop till the storm was over, and then went to his house, where he found his parents and friends much more surprised than he had been himself; who, after expressing their astonishment, informed him, that he appeared to them (during the time he was raising the kite) to be in the midst of a large bright flame of fire, attended with flashings; and that they expected every moment to see him fall a sacrifice to the flame.*

Having succeeded so completely with his electrical kite, Dr. Franklin determined to persevere in his observations. He accordingly erected an insulated iron rod,† on purpose to draw the lightning into his house, to make experiments whenever there should be a considerable quantity of it in the atmosphere; and, that he might not lose any opportunity of that nature, he connected two bells with his apparatus, which gave him notice by ringing, whenever his rod was electrified.

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* Professor Richman of Petersburgh, afterwards as he was pursuing these experiments (so happily begun by Dr, Franklin) was struck dead in the midst of his family.

NYMPHS! on that day ye shed from lucid eyes
Celestial tears, and breathed ethereal sighs!
When RICHMAN rear'd, by fearless haste betray'd,
The wiry rod in Nieva's fatal shade;—
Clouds o'er the sage, with fringed skirts succeed,
Flash follows flash, the warning corks recede,
Near and more near he ey'd with fond amaze
The silver stream, and watch'd the sapphire blaze;
Then bursts the steel, the dart electric sped,
And the bold sage lay number'd with the dead!

DARWIN.

† This discovery, although it seemed to the ignorant and superficial to be only a matter of curiosity and surprise, was attended with consequences highly beneficial to the human race. The grand practical use which our author converted it to, was, to prevent buildings from being damaged by lightning. This he accomplished by fixing a metallic rod higher than any part of the edifice, and contriving it in such a manner as to communicate with the earth, or rather with the nearest water. The lightning was sure to seize upon the rod, preferably to any other part of the building, and that dangerous element, instead of committing its usual destruction, was harmlessly brought in contact with the ground, without doing any mischief whatever.

JUPITER, the supreme god of the ancients, being thus disarmed of his terrors, the subject was taken up with the utmost philosophical ardour.

Thunder storms, says Beccaria, generally happen when there is little or no wind, and their first appearance is marked by one dense cloud, or more, increasing very fast in size, and rising into the higher regions of the air; the lower surface black, and nearly level, but the upper finely arched, and well defined. Many of these clouds seem frequently piled one upon another, all arched in the same manner; and they keep continually uniting, swelling, and extending the arches.

At the time of the rising of this cloud, the atmosphere is generally full of a great number of separate clouds, motionless, and of odd and whimsical shapes. All these, upon the appearance of the thunder cloud, draw towards it, and become more uniform in their shapes as they approach, till coming very near the thunder cloud, their limbs mutually stretch towards one another; they immediately coalesce, and together make one uniform mass.

When the thunder cloud is grown to a great size, its lower surface is often ragged, particular parts being detached towards the earth, but still connected with the rest. Sometimes the lower surface swells into various large protuberances, bending uniformly towards the earth. When the eye is under the thunder cloud, after it is grown larger, and well formed, it is seen to sink lower, and to darken prodigiously, at the same time that a number of small detached clouds (the source of which can never be perceived) are seen in a rapid motion, driving about in a very uncertain direction under it.

A cloud in a thunder storm may be considered as a great conductor, actually insulated and electrified;* and it may be supposed to have the same effect upon those non-electrics which it meets with in its course, as our common conductors have upon those which are presented to them. If a cloud of this kind meets with another which is not electrified, or less so than itself, the electric matter flies off from all parts towards this cloud; hence proceed flashes of lightning, and the formidable report of thunder.

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* Professor Saussure, when passing the Alps, meeting with thunder-clouds, found his body immediately replete with the electric fluid, and having insulated himself by means of a stool with glass feet, his companion Mons. Galabert observed his hair to stand an end, and sparks were drawn from him with a crackling noise, as in those electrified by art. This is another corroboration of the truth of Dr. Franklin's great discovery.

The zig-zag kind of lightning is extremely dangerous, because it must overcome a very violent resistance of the atmosphere, and wherever that resistance is in the smallest degree lessened, there it will undoubtedly strike, and even at a considerable distance. It is otherwise with that kind which appears in flashes of no determinate form; the electric matter of which is evidently dissipated in the air by some conducting substances which are present there, and they are therefore rendered less powerful.

The most destructive kind of lightning is that which assumes the form of balls. These are produced by an exceeding great power of electricity, gradually accumulated till the resistance of the atmosphere is no longer able to confine it. In general, the lightning breaks out from the electrified cloud by means of the approach of some conducting substance; but the fire-balls seem to be formed not because there is any substance at hand to attract the electric matter from the cloud, but because the electricity is accumulated in such a quantity that the cloud can no longer contain it. Hence, such balls fly off slowly, and have no particular destination; their appearance indicates a prodigious commotion and accumulation of electricity in the atmosphere, without a proportionable disposition in the earth to receive it.

From a number of observations, the indefatigable Beccaria also endeavours to account for the rising of vapours and the fall of rain, upon electrical principles; and, it must be confessed, that if it is not a primary agent in these effects, it would be rashness entirely to deny its influence. This philosopher supposes, that previous to rain a quantity of electric matter escapes from the earth, and in its ascent to the higher regions of the air collects and conducts into its path a great quantity of vapours. The same cause that collects will condense them more and more, till in the places of the nearest intervals they come almost in contact, so as to form small drops, which, uniting with others as they fall, come down in rain. The rain he supposes to fall heavier in proportion as the electricity is more vigorous.

Hail, he supposes to be formed in the higher regions of air, where the cold is intense, and where the electric matter is very copious. In these circumstances, a great number of particles of water are brought near together, where they are frozen, and in their descent collect other particles; so that the density of the substance of the hail-stone grows less and less from the center, this being formed first in the higher regions, and the surface being collected in the lower. Agreeably to this, it is observed, that on mountains, hail-stones and drops of rain are very small,[*] there being but a small space through which they can fall.

Clouds of snow differ in nothing from clouds of rain, but in the circumstance of the cold which freezes them.[†]

Low and thick fogs (especially when as they rise the air above them is free from moisture) carry up to the exploring wire an electricity which will give small sparks repeatedly, and produce a divergence of the balls [‡] from

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[*] Clouds consist of very small globules, which are repelled from each other by the power of electricity, and when these, from a deficiency of this fluid, assemble together by the natural adhesive attraction possessed by homogeneous bodies, it is then that the *shower* descends, as these are no longer buoyant, and still losing the elastic influence from the earth being in a negative state with respect to the air, the drops increase and assume a decided form. This is beautifully illustrated by hanging a small metallic vessel containing water on the conductor of an electrical apparatus, with a capillary syphon affixed to it. The water from the syphon falls in drops: but *when electrified,* these divide into numberless smaller ones, so as to resemble what is called a Scotch mist, i. e. the rain on the tops of mountains, or those November mists when the equilibrium of the electric fluid is on the earth, and in the heavens nearly equipoised.

[†] This phænomenon is often seen in crowded assembly-rooms at Petersburgh. When the cold air is let in from the top of the room by a contrivance on purpose for ameliorating the air, the floating vapour will be suddenly frozen, and attach together, and fall down in the form of thin flakes of snow. That snow is composed of a congeries of small spicula, is proved from the following pleasing experiment. Take a tall phial of the nitrous acid, warm it, add to it the filings of silver by degrees, which will dissolve. The phial being placed in a cold window, as it cools, the silver particles will shoot into crystals; several of these uniting will form a flake, and these precipitating from their increased weight, will fall to the bottom of the phial, as silver flakes, and one flake lie upon another, like those of snow. The lightness of snow, although in fact solid ice, is merely owing to the extent of surface, as the silver in the above experiment, or as gold can be so extended in surface, as to ride upon the least breath of air. Its whiteness is owing to the smallness and disjunction of the spicula forming its composition, for ice when pounded will appear equally white. For further particulars respecting snow, vide Section xiii, page 70.

[‡] Balls of pith insulated and suspended shew the quantity, or power of the electric fluid. Thus if suspended in a fog or mist they separate with positive electricity.

The terms *positive* and *negative,* as applied to electricity, are thus explained by Dr. Franklin. "Positive electricity is when there is an accumulation of the electric fluid, or too great a quantity in any body, and negative when there is a deficiency."

When the remarkable phænomenon of the charged phial was discovered by Muschenbroek at Leyden, no plausible theory was advanced for its explanation previous to Dr. Franklin. From some experiments he was induced to suppose that electricity was a single elementary fluid, which he termed electrical fire; and that its phænomena depended upon the different proportions in which it is formed; that this fire was equally diffused throughout all bodies, and when, upon any disturbance, there was more than the natural quantity accumulated, this excess he expressed by the term positive; and when there was any deficiency, such was implied by the term negative. This philosopher supposes twenty particles of electricity on the inside, and the same quantity on the outside; so that when the quantity withinside was doubled, the whole of the outside was expelled. Glass, according to Dr. Franklin, is not permeable to electricity. These two electricities have been since denominated the *vitreous* and *resinous.* In the year 1733, Mons. Du Faye, intendant of the French King's gardens, and member of the Academy of Sciences at Paris, discovered, as he thought, two opposite and distinct species of electricity, which he termed the vitreous and resinous. "Chance," says this philosopher, has "thrown in my way an universal principle, which casts a new light upon the subject of electricity.

20°to 25°, or even 30°. If the fog grows sluggish, and continues round the exploring wire, the electricity soon fails; but if it continues to rise, and ano-

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The principle is, that there are two distinct kinds of electricity, very different from one another; one of which I call vitreous, and the other resinous electricity. The first is that of glass, rock crystal, precious stones, hair of animals, wool, and many other bodies. " The second is that of amber, copal, gum lac, silk, thread, paper, and a vast number of other substances."

" The characteristic of the two electricities is, that they repel themselves, and attract each other. Thus a body of the vitreous electricity repels all other bodies possessed of the vitreous; and, on the contrary, attracts all those of the resinous electricity. The resinous also, repels the resinous, and attracts the vitreous. From this principle, one may easily deduce the explanation of a great number of phænomena; and it is probable, that this truth will lead us to the discovery of many more things."

The difficulties attending the Franklinian System, respecting the impermeability of glass, induced Messrs. Eeles, Symner, Atwood, and others, to adopt the idea of Du Faye, of there being two distinct kinds of electricities; with this difference, Du Faye supposed the electricities existed naturally different in different bodies, while these gentlemen suppose, that the two electricities are always united, and only evince their power when separated; that when in union they counteract each other, so as in this state are perfectly tranquil. When they are divided, they each have uncontrolled their separate power; and their strong attractive nisus to unite, is the cause of every electrical appearance.

By thus regarding electricity as a compound of two distinct principles, which, when divided, will permeate glass, they thus attempt to explain the *Leyden Phial.*

These two principles they term, after Du Faye, the vitreous and resinous electricity; and farther assume, that similar electricities repel each other, and contrary electricities attract.

By the action of the rubber on the cylinder, the electricities of the rubber are decomposed; that the vitreous portion is separated and given to the cylinder, and takes back as much resinous electricity; the cylinder gives out the vitreous portion it has just received to the conductor, and receives back an adequate portion of resinous electricity; the conductor imparts this vitreous portion to the inside of the Leyden jar, and takes back its resinous portion; this additional vitreous portion repels the vitreous portion from the outside, while the resinous portion on the outside is attracted within. At this period there is no electricity on the outside, but what is uncombined; hence, with rapidity, will attract the opposite electricity, when it meets with no resistance.

In general clouds shew the positive electricity, but in thunder storms there is a quick transition from positive, or vitreous, to negative, or resinous, and this continues until the battling clouds appear to lose their resinous electricity, and the positive, or vitreous state is established. Such is the explanation of the thunder-storm by those who espouse the doctrine of two contrary electrics. Thus if we consider the clouds as one of the coating of the Leyden phial, the lower dense air, as the glass, or electric, and the earth as the other coating, we may contemplate the Leyden bottle upon a grand scale, producing thunder, lightning, earthquakes, and the aurora-borealis. Fig. 33, *a*, is a portion of the earth's surface; *c* the lower non-conducting part of the atmosphere; *d* the clouds; *g* the positive electricity of the clouds, met by the negative, *q*, of the earth; *n* the explosion; *z z* the electric stream from the sun. When the air is very dry, and much saturated with electricity, it resists the entrance of more; and hence the reason why thunder generally follows such weather, and is more prevalent in summer than winter. When the air is moist, electricity finds an easy passage into the earth, without commotion; and hence the earth has been generally considered as the grand reservoir of it; and from that reservoir we pump it by electric machines and other frictions, being incapable by such means of exciting much from the air. When the rays of electricity, therefore, come the most directly on the earth, as in summer, a greater quantity may be poured on the dry air than it can conduct, and hence the clouds will be in a positive or abundant state, while the earth, comparatively, may be in a negative state; the consequence will be a violent effort to restore equality by a storm of thunder and lightning; and the air near the earth will be found positive and negative by fits, while the storm lasts. When the clouds are scattered at a distance from one another, the lightning is often seen darting from one to another, where the air is ther cloud succeeds, it electrifies again the wire, though less than before. Sky-rockets sent through such thick, low, and continued fogs, often afford signs of electricity.

Dr. Franklin's theory is as follows. The electric fluid, says this ingenious philosopher, is strongly attracted by water; and by destroying the cohesion between its particles, and repelling them from each other, it becomes a powerful agent in evaporation.* The waters of the ocean abound in this

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too rare or thin to form much resistance to its passage, and then we see lightning without hearing thunder. An humble imitation of those effects may be produced by the two circular boards, Fig. 26, about two feet in diameter, their edges rounded, and the whole covered with tin-foil. Let one be suspended from the ceiling by clean silken cords; and the other sustained on glass feet, parallel to the other; but so as to be brought nearer or farther from another. If the upper board be connected with the conductor, and the lower with the earth, and separated about two inches distant, and electrified; one hand touching the lower, and the other the upper, a shock will be received as far from the Leyden bottle; for, as has been shewn, it is but a plate of air that is charged instead of a plate of glass; the upper board being in a positive, and the under in a negative, state: the shock being in proportion to the quantity of electricity, and the ease with which it can escape from the positive side of the electric. The two plates strongly attract each other, and would come together, if not kept asunder by force: sparks flying between them will frequently destroy the electricity of each. If the under surface of the upper plate be covered with gilt leather, and a smooth shilling be laid on the lower plate, beautiful ramifications will fly about the leather, and dart to the shilling, when electrified. In this experiment the upper plate naturally represents a positive cloud, and the under one the earth, with the manner in which lightning darts from the clouds to the earth; and if a Leyden phial be connected with the conductor, the flash and report will be still the greater. Vide Walker's Philosophy.

* Those who have not been accustomed to contemplate the occurrences of natural events will be astonished to be informed, that an acre of ground, even after having been parched by the heat of the sun in summer, disperses into the air above one thousand six hundred gallons of water, in the space of twelve hours. The experiment from which this conclusion is drawn is as follows. On the 2d of June, 1779, when the sun shone bright and hot, I put, says the learned bishop of Landaff, a large drinking glass, with its mouth downwards, upon a grass-plat which was mown close; there had been no rain, for above a month, and the grass was become brown; in less than two minutes the inside of the glass was clouded with a vapour, and in half an hour drops of water began to trickle down its inside, in various places. This experiment was repeated several times with the same success. That I might accurately estimate the quantity, thus raised, in any certain portion of time, I measured the area of the mouth of the glass, and found it to be 20 square inches: there are 1296 square inches in a square yard, and 4840 square yards in a statute acre; hence, if we can find the means of measuring the quantity of vapour raised from 20 square inches of earth, suppose in one quarter of an hour, it will be an easy matter to calculate the quantity which would be raised with the same degree of heat, from an acre in 12 hours. The method I took to measure the quantity of vapour, was not perhaps the most accurate which might be thought of, but it was simple and easy to be practised: when the glass had stood on the grass-plat one quarter of an hour, and had collected a quantity of vapour, I wiped its inside with a piece of muslin, the weight of which had been previously taken; as soon as the glass was wiped dry, the muslin was weighed again, its increase of weight shewed the quantity of vapour which had been collected. The medium increase of weight, from several experiments made on the same day, between 12 and 3 o'clock, was six grains collected in one quarter of an hour, from 20 square inches of earth. If the reader takes the trouble to make the calculation, he will find that above 1600 gallons, reckoning 8 pints to a gallon, and estimating the weight of a pint of water at one pound avoirdupois, or 7000 grains troy weight, would be raised, at the rate here mentioned, from an acre of ground in 24 hours.

It may easily be conceived, that the quantity thus elevated will be greater when the ground has electric fire, and vapours raised from them float in the air, forming clouds, which retain their electricity till they meet with other bodies, either destitute of it,

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been well soaked with rain, provided the heat be the same. I did not happen to mark the heat of the ground when I made the fore-mentioned experiments; the two following are more circumstantial: the ground had been wetted the day before I made them by a thunder shower, the heat of the earth, at the time of making them, estimated by a thermometer laid on the grass, was 96 degrees; one experiment gave 1973 gallons from an acre in 12 hours, the other gave 1905. Another experiment, made when there had been no rain for a week, and the heat of the earth was 110 degrees, gave after the rate of 2800 gallons from an acre in 12 hours; the earth was hotter than the air, as it was exposed to the reflexion of the sun's rays from a brick wall.

To shew how much *electricity* has to do with this phænomenon, the learned bishop made afterwards the following experiments. Upon the same grass-plat, and contiguous to the glass used in these experiments, I placed a silver cup, with its mouth downwards, of a shape similar to that of the glass, and nearly of the same dimensions; but I could never observe that its inside had collected the least particle of vapour, though I frequently let it stand on the grass for half an hour, or more.

By means of a little bees-wax, I fastened an half crown very near, but not quite contiguous, to the side of the glass, and setting the glass, with its mouth downwards, on the grass, it presently became covered with vapour, except that part of it which was near to the half-crown. Not only the half-crown itself was free from vapour, but it had hindered any from settling on the glass which was near it, for there was a little ring of glass surrounding the half-crown to the distance of three quarters of an inch which was quite dry, as well as that part of the glass which was immediately under the half-crown; it seemed as if the silver had repelled the water to that distance. A large red wafer as containing lead had the same effect as the half-crown; it was neither wetted itself, nor was the ring of glass contiguous to it wetted. A circle of white paper produced the same effect, so did several other substances, which it would be tedious to enumerate.

These phænomena respecting the different dispositions of different bodies to attract the *rising* vapour, are similar to what others have noticed concerning the *falling* of dew, and are, probably, to be explained upon the same principles, whatever they may be. Muschenbroek placed on the leaden terrace of the Observatory at Utretcht, vessels of glass, china, varnished wood, polished brass, and pewter: he found that in the course of a night the glass, china, and varnished wood, had collected a great abundance of dew, but that not a drop had fallen on any of the polished metals. M. Du Faye exposed to the air, when the dew was falling, two large funnels, one made of glass, the other of polished pewter; the necks of the funnels being inserted into vessels proper to retain any moisture which might be collected by them; he sometimes found in the morning that the vessel under the glass funnel contained an ounce of more water, but he never observed so much as a drop in the other. These experiments are found to correspond with those of the Abbé Nollet, who found, that evaporation of all fluids was accelerated by electricity, hence their quick and sudden ascension in capillary vessels, from this power, and hence their quicker diffusion in the air, when contained in metallic vessels than in those fabricated of glass.

Thus it is that *evaporation* is the product of both heat and electricity, and water rises in the air, flying on the wings of electricity, till it arrives at those cold and rare regions, which is a conductor of electricity (for air approaching to a vacuum is found to be a conductor). To this thin, or rare air, electricity has a greater affinity than to water, the water becomes in part forsaken, and its particles attracting each other, lose their transparency, and clouds are generated, which drop, according to the respective densities of the stratas of air. If still more electricity be withdrawn then *rain* is produced: or that *haziness* which is sometimes seen to proceed on a sudden, overcasting, what appeared but a few minutes before, the brightness of an universal azure, which can be accounted for upon no other principle. That evaporation, clouds and rain are thus produced, may be elegantly illustrated by hanging a pair of small pith balls, by flaxen threads, in a receiver, and electrifying them positively: if the receiver be placed on the air-pump, and exhausted, the balls will close; but when the vapour becomes forsaken, and descends in the receiver, the balls open with negative electricity, shewing that the rarefied air absorbed the electricity, and left the water to which it was united; thus completely forsaken, it falls within the receiver, an actual shower of rain.

or containing it in a less proportion than themselves. This, in all probability, is frequently the case with those vapours or clouds which are produced by exhalations from the earth, from fresh water, and the perspiration of plants and trees; at least it is an undoubted fact, that some clouds (to use the language of this branch of philosophy) are electrified *positively,* and others *negatively.* No sooner does a communication take place, but the repulsion between the particles of water is diminished, those which have discharged part of their electricity are successively attracted by the contiguous ones which have not, and thus they press nearer together, become specifically heavier than the atmosphere, and descend in small drops, which, losing every instant more and more of the electric fire, coalesce, uniting into larger and larger drops, and consequently filling a space which is continually diminishing, as they approach nearer to the surface of the earth. This may be illustrated by electrifying the stream of a fountain, which will spread itself into the form of a brush by the mutual recession of the particles of water: but withdraw the supply of electric fire, and the fountain discharges itself in one continued current.* A pair of cork balls suspended together by silken threads, when electrified recede from each other, and if the air be dry, return by degrees only to their natural position. Two feathers electrified will float in the atmosphere, mutually repelling each other, when in a certain degree of contiguity, and gradually descending as they lose that power, which by expanding their *plumulæ,* rendered them specifically lighter than the air. But if one of them discharges suddenly the electric fire, it will instantly be attracted towards the other, and receive a fresh supply; when a repulsion (acting indeed at a much less distance than before) will again take place between them.

When two clouds, one replete with electric fire, the other destitute of it, come within the sphere of each other's attraction, they will rush together, and the electrical fluid being diffused through a larger space, the particles of water will unite, and form themselves into drops of greater magnitude, and a heavy shower will be produced. Still however as the rain descends through an atmosphere containing little electric fire, it will be continually communicating it, and the discharge being greatest from the circumference of the cloud, because the surface is there largest, the drops will be drawn nearer and nearer to each other, and, approaching towards one common centre, will gradually coalesce in their passage.

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* Vide Note page 157.

Doctor Franklin has related a most ingenious experiment, which elucidates the formation of rain as thus described.

Take round pieces of pasteboard of two inches diameter; from the centre and circumference of each of them suspend, by fine silk threads eighteen inches long, seven small balls of wood, or seven peas equal in bigness; so will the balls appending to each pasteboard form equal equilateral triangles, one ball being in the centre, and six at equal distances from that and each other; and thus they represent particles of air. Dip both sets in water, and, some adhering to each ball, they will represent air loaded. Dexterously electrify one set, and its balls will repel each other to a greater distance, enlarging the triangles. Could the water supported by the seven balls come into contact, it would form a drop or drops so heavy as to break the cohesion it had with the balls, and so fall.

Let the two sets then represent two clouds, the one a sea cloud electrified, the other a land cloud; bring them within the sphere of attraction, and they will draw towards each other, and you will see the separated balls close thus:— The first electrified ball that comes near an unelectrified ball, by attraction, joins it and gives it fire; instantly they separate, and each flies to another ball of its own party, one to give, the other to receive fire; and so it proceeds through both sets, but so quick as to be, in a manner, instantaneous. In their collision they shake off and drop their water, which will represent rain.

But it rarely happens, that a land cloud is equal in magnitude to one raised from the sea; consequently the rain produced by their union, will be proportionably lighter in the upper, and heavier in the lower regions of the atmosphere, as the electric matter is more or less gradually diffused.

When an electrified cloud, without mixing with another cloud, or losing part of its electric fire, becomes specifically heavier than the atmosphere, by cold, or some local change in the density of the air, it will descend at first perhaps in a mist; or will form, as it approaches nearer to the earth, and is less replete with the electric fluid, a light shower of rain.

In confirmation of this doctrine is the discovery of the late Dr. Heberden, which was read before the Royal Society, Dec. 7, 1769. This amiable and sagacious physician writes as follows:

A comparison having been made between the quantity of rain which fell in two places in London, about a mile distant from one another, it was found that the rain in one of them constantly exceeded that in the other, not only every month, but almost every time that it rained.

The apparatus used in each of them was very exact, both being made by the same artist; and upon examining every probable cause, this unexpected variation did not appear to be owing to any mistake, but to the constant effect of some circumstance, which not being supposed to be of any moment, had never been attended to. The rain-gauge in one of these places was fixed so high as to rise above all the neighbouring chimnies; the other was considerably below them; and there appeared reason to believe, that the difference of the quantity of rain in these two places was owing to this difference in the placing of the vessel in which it was received. A funnel was therefore placed above the highest chimnies, and another upon the ground of the garden belonging to the same house, and there were found the same difference between these two, which there had been between them, when placed at similar heights in different parts of the town. After this fact was sufficiently ascertained, it was thought proper to try, whether the difference would be greater at a much greater height; and a rain-gauge was therefore placed upon the square parts of the roof of Westminster Abbey, being at such a distance from the western towers as probably to be very little affected by them, and being much higher than any other neighbouring buildings.

Here the quantity of rain was observed for a twelvemonth, the rain being measured at the end of every month, and care being taken, that none should evaporate, by passing a very long tube of the funnel into a bottle through a cork, to which it was exactly fitted. The tube went down very near to the bottom of the bottle, and therefore the rain, which fell into it, would soon rise above the end of the tube, so that the water was no where open to the air except for the small space of the area of the tube: and by trial it was found, that there was no sensible evaporation through the tube thus fitted up.

The following table will shew the result of these observations.

From July the 7th, 1766, to July the 7th, 1767, there fell into a rain-guage fixed

	Below the top of a house.	Upon the top of a house.	Upon Westminster Abbey.
	Inches.	Inches.	Inches.
1766, From the 7th of July to the end	3,591	3,210	2,311
August	0,558	0,479	0,508
September . . .	0,421	0,344	
October	2,364	2,661	1,416
November . . .	1,079	0,842	0,632
December . . .	1,612	1,258	0,994
January	2,071	1,455	1,035
February	2,864	2,494	1,335
March	1,807	1,303	0,587
April	1,437	1,213	0,994
May	2,432	1,745	1,142
June	1,977	1,426	1,145
From the 1st of July to the 7th . . .	0,395	0,309	
	22,608	18,139	12,099

By this table it appears, that there fell below the top of a house above a fifth part more rain than what fell in the same space above the top of the same house, and that there fell upon Westminster Abbey not much above one half of what was found to fall in the same space below the top of the houses. What may be the cause of this extraordinary difference, adds Dr. Heberden, has not yet been discovered; but it may be useful to give notice of it, in order to prevent that error, which would frequently be committed in comparing the rain of two places without attending to this circumstance.

It is probable, that some hitherto unknown property of *electricity* is concerned in this phænomenon. This power has undoubtedly a great share in the descent of rain, which hardly ever happens, if the air and electrical apparatus be sufficiently dry, without manifest signs of electricity in the air. Hence it is, that in Lima, where there is no rain, they never have any lightning or thunder *; and that, as M. Tournefort was assured, it never rains in the Levant but in winter, and that this is the only season in which any thunder is heard†. If this appearance therefore could be accounted for, it would probably help us to some more satisfactory causes of the suspension of the clouds, and of the descent of rain.

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* See the English translation of the Voyage of Don George Juan and Don Antonio de Ulloa, to South America, Vol. III. Book I. chap. 6. p. 69 and 79.

† Voyage du Levant, Let. x. p. 423.

The Aurora Borealis is too much connected with our subject, and so extraordinary a phænomenon, that we must beg farther to intrude upon the patience of our candid reader.

Franklin was also the first who has attempted a reasonable hypothesis respecting the aurora borealis. He reasons thus. Air heated by any means becomes rarefied, and specifically lighter than other air in the same situation not heated, and when lighter it rises, and the neighbouring cooler and heavier air takes its place. If in the middle of a room you heat the air by a stove, or pot of burning coals, near the floor, the heated air will rise to the ceiling, spread over the cooler air till it comes to the cold walls; there being condensed and made heavier, it descends, to supply the place of that cool air which had moved towards the stove or fire, in order to supply the place of the heated air which had descended. Thus there will be a continual circulation of air in the room, which may be rendered visible by making a little smoke, for that smoke will rise and circulate with the air.

A similar operation is performed by nature on the air of this globe. Above the height of our atmosphere the air is so rare as to be almost a vacuum. The air heated between the tropics is continually rising; its place is supplied by northerly and southerly winds, which come from the cooler regions. The light heated air floating above the cooler and denser, must spread northward and southward, and descend near the two poles, to supply the place of the cool air, which had moved towards the equator. Thus a circulation of air is kept up in our atmosphere, as in the room above mentioned. That heavier and lighter air may move in currents of different and even opposite direction, appears sometimes by the clouds that happen to be in those currents, as plainly as by the smoke in the experiment above mentioned; also, in opening a door between two chambers, one of which has been warmed; by holding a candle near the top, near the bottom, and near the middle, you will find a strong current of warm air passing out of the warmed room above, and another of cool air entering below, while in the middle there is little or no motion.

The great quantity of vapour rising between the tropics forms clouds, which contain much electricity;* some of them fall in rain, before they come to the polar regions. Every drop brings down some electricity with it; the same is done by snow or hail, the electricity so descending, in temperate climates, is received and imbibed by the earth. If the clouds are not sufficiently discharged by the gradual operation, they sometimes discharge themselves suddenly by striking into the earth, where the earth is fit to receive their electricity. The earth in temperate and warm climates is generally fit to receive it, being a good conductor.

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* The meteors of the torrid zone are different from those which are found near the polar circles; for there the sun exerting his greatest force, raises vapours of various kinds, which form a great variety

The humidity contained in all the equatorial clouds that reach the polar regions, must there be condensed, and fall in snow. The great cake of ice that eternally covers those regions may be too hard frozen to permit the electricity, descending with that snow, to enter the earth. It may therefore be accumulated upon that ice. The atmosphere being heavier in the polar regions than in the equatorial, will there be lower; as well from that cause, as from the smaller effect of the centrifugal force: consequently the distance of the vacuum above the atmosphere will be less at the poles than elsewhere, and probably much less than the distance (upon the surface of the globe) extending from the pole to those latitudes in which the earth is so thawed as to receive and imbibe electricity. May not then the great quantity of electricity brought into the polar regions by the clouds, which are condensed there, and fall in snow, which electricity would enter the earth, but cannot penetrate the ice; may it not, as a bottle overcharged, break through that low atmosphere, and run along into the vacuum over the air towards the

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of meteors. Upon the approach of the winter months, as they are called, under the line, the sky, from a fiery brightness, begins to be overcast, and the whole horizon seems wrapped in a muddy cloud. Mists and vapours still continue to rise; and the air, which so lately before was clear and elastic, now became humid, obscure, and stifling: the fogs became so thick, that the light of the sun seems in a manner excluded; nor would its presence be known, but for the intense and suffocating heat of its beams, which dart through the gloom, and, instead of dissipating, only serve to increase the mist. After this preparation, there follows an almost continual succession of thunder, rain, and tempests. During this dreadful season, the streets of cities flow like rivers, and the whole country wears the appearance of an ocean. The inhabitants often make use of this opportunity to lay in a stock of fresh water for the rest of the year; as the same cause which pours down the deluge at one season, denies the kindly shower at another. The thunder which attends the fall of these rains, is much more terrible than what we are generally acquainted with. With us, the flash is seen at some distance, and the noise shortly after ensues; our thunder generally rolls on one quarter of the sky, and one stroke pursues another. But here it is otherwise; the whole sky seems illuminated with unremitted flashes of lightning; every part of the air seems productive of its own thunders; and every cloud produces its own shock. The strokes become so thick, that the inhabitants can scarce mark the intervals; but all is one unremitted roar of elementary confusion. Vide PAINE'S GEOGRAPHICAL EXTRACTS, a very amusing and instructive work.

equator; diverging as the degrees of longitude enlarge; strongly visible where densest, and becoming less visible as it more diverges; till it finds a passage to the earth in more temperate climates, or is mingled with the upper air? If such an operation of nature were really performed, would it not give all the appearance of an *aurora borealis?* And would not the auroras become more frequent after the approach of winter; not only because more visible in longer nights, but also because in summer the long presence of the sun may soften the surface of the great ice-cake, and render it a conductor, by which the accumulation of electricity in the polar regions will be prevented?"

Nature has done most, where her efforts seem most wanted. In Sect. XIII. we showed the peculiarity of the Lapland year, and we cannot help now observing her kindness, when the sun no longer spreads his influence of light, by substituting the powers of the electric fluid.

> By dancing meteors then, that ceaseless shake
> A waving blaze refracted o'er the heavens,
> And vivid moons, and stars that keener play
> With double lustre from the glossy waste;
> Ev'n in the depth of *polar night* they find
> A *wondrous* day: enough to light the chase,
> Or guide their daring steps to Finland fairs.
>
> THOMSON.

As soon as the Lapland winter ceases, besides the oxygenation of the earth from the melting snows, the accumulated electric fluid penetrates the ground, and aids the other powers in accelerating the growth of plants.

That the electric fluid has some sensible effect upon vegetation, even common observation has pointed out.

It has been universally noticed that grass grew stronger in patches where the earth had been struck with lightning, and that there mushrooms would spring up.

This increased fertility of soil were denoted *fairy rings* by vulgar superstition, who seeing the effect were wont to attribute it to a supernatural cause. I remember, says Dr. Darwin, some circles of many yards diameter of this kind near Foremark, in Derbyshire, which annually produce large white funguses, and stronger grass, and have done this, I am credibly informed, more than thirty years.

Experiments have been purposely made with the electric fluid to ascertain its influence on vegetation.

The famous Abbé Nollet, after having discovered the quicker rise of water in capillary tubes from the addition of the electric fluid, and the faster flow of the blood in the animated body, instituted some experiments on plants.

EXPERIMENT FIRST.

He took garden-pots, and filled them with the same kind of earth, and sowed them with the same kind of seed.

He kept them constantly in the same place, and the same position as to light, and gave each the same quantity of water: but one was electrified daily from two to three, and sometimes four hours, a day.

The consequence was, the electrified pot shewed its germs by *three days sooner* than *the other*. It had longer shoots in a given time, and looked more vigorous withal.

The Abbé Berthollon next drew the attention of the learned world to this subject, and having opened the glorious career, many other philosophers followed the same path, among whom the L'Abbé D'Ormoy's Experiments seem the most conclusive.

SECOND AND THIRD EXPERIMENTS.

On the 21st of March, 1788, I electrified, says the Abbé D'Ormoy, during the space of twelve hours, a *magic board,* recharging it successively, when the electricity was diminished. Upon this machine, the surface of which was covered, about a foot and a half square with the tin, I put twelve grains of the small Radishes and twenty grains of Lettuce.

These electrified seeds were sown on the same hour of the day, with the like quantity of the same seeds not electrified, taken out of the same parcels, and sown on the same mould; they were covered exactly with the same proportion of earth, placed in the same exposition to the sun, air, and light, and in every respect were treated alike.

March 27th, every one of the twelve *electrified* grains of Radishes appeared.

Whereas at noon on the 28th, nine only of the *non-electrified* began to make their appearance.

March 30th, I saw, at five in the morning, all the *electrified Lettuce,* which announced their having sprouted out during the night.

FOURTH EXPERIMENT.

On the 30th and 31st of March, I electrified twelve hips of a ROSE-TREE, which were taken out of a bundle that for four years had been repeatedly sown without effect. I placed them upon the machine, which I charged with the electric fluid, along with my servant, from eight in the morning until nine at night.

On the evening of the 31st, I put them into a small vessel, containing a certain quantity of water. This apparatus, with the necessary communications, I placed on the above-mentioned machine, which I charged every hour, during nine days.

At the same time twelve non-electrified hips were steeped in water, non-electrified, for the same number of days.

These were afterwards sown in the same mould, similarly exposed in every respect, and on the 19th of April, I discovered, in the morning, a plant of the rose-tree; some others appeared in the evening; and a fifth came up the next day, in the garden-pot containing the electrified hips. But not one of the non-electrified hips ever came out of the ground.

FIFTH EXPERIMENT.

On the 7th of February, I electrified some LUPINE SEEDS in three different manners:

1st, By wrapping some up in a sheet of tin, and placing them upon the tableau magique.

2dly, By placing some simply on the tableau magique.

3dly, By giving other several electrical shocks.

On the 7th, 8th, 9th, and 10th, they were electrified by charging the tableau magique at different intervals of time, from morning until evening.

On the 10th, in the evening, these were sown in pots filled with earth.

At the same time a similar quantity of non-electrified lupines were also sown.

Before sowing I made use of the following precaution. I watered the sifted mould, and when it had acquired a due consistence I made holes of half an inch deep, and placed every seed with the eye downwards. All the vases were alike exposed, and treated in the same way.

On the 18th of February, at five o'clock in the morning, the seeds first enclosed in tin, and electrified, appeared.

At eight o'clock the seeds simply electrified on the tableau magique shewed themselves.

And at ten to eleven those electrified by the shock were visible.

But the non-electrified seeds did not shew themselves until the morning of the 19th.

On the 2d of March it occurred to me to dig up the seeds I had sown in the different pots, and to measure their respective heights.

I took them up with considerable precaution; and I observed at the very first glance that those plants, which were formerly electrified, were considerably larger than the non-electrified.

Upon a more particular examination I found,

1st, That the non-electrified had struck a very little way into the ground, whereas the other had penetrated deep, and had shot out a number of small roots. I counted as many as thirty to one plant electrified in the first manner.

2d, The plants, from the lupins wrapped in tin, during their electrisation, measured from the top of the stalk to the extremity of the root five inches.

3d, One of the plants from the seed, simply electrified on the magic table, measured three inches eight lines and a half, and others three inches six lines.

4th, Those from the seeds, which received the shocks, were two of them four inches and a half, the other three inches ten lines.

5th, The longest of the non-electrified plants were not more than three inches four lines, and on the average not above two inches and a half.

6th, The electrified plants appeared equally healthy with the others.

SIXTH EXPERIMENT.

On the 11th of February I repeated the same experiment with other LUPINS.

On the 1st of March twenty-six of the seeds electrified on the tableau magique had vegetated, so as to appear above ground, and the remainder of them made their appearance the next morning.

On the 2d instant I reckoned ten plants from the seeds electrified by shocks, and in the course of the same day the rest appeared.

On the 3d of March, in the evening, some of the non-electrified seeds had vegetated; but it was not until the 4th and 5th of the same month that the rest became visible, at which time

The plants from the seeds, electrified in the first manner, had arrived at the height of eleven lines;

Those of the second were six or seven lines high;

Whilst the non-electrified were not more than from two to four lines high.

SEVENTH EXPERIMENT.

From six o'clock in the morning until twelve at noon, on the 31st of January, 1789, I electrified every half hour fifty grains of the Nasturtium (*Lepidium sativum*), placed on the *magic table.*

At a quarter after twelve, the same day, I sowed them in a vase filled with mould; on the same day, and at the same hour, I sowed, in another vase filled with the same mould, fifty grains of the same plant, taken from the same parcel, but not electrified.

I paid exactly the same attention to both vases; and above all, I took care to place them both absolutely in the same degree of light.

February 2d, about ten o'clock at night, six of the electrified grains of nasturtium rose out of the ground.

February 4th, in the evening, it was before the non-electrified grains appeared.

The difference as to heights, after some days had passed, was sufficiently striking to all to whom I showed them. They at once noticed to the rest, those plants, whose seeds, previous to being sown, had been electrified.

EIGHTH EXPERIMENT.

March 3d, I sowed in two pots, filled with mould, twenty-four grains of rye, twelve grains in each pot.

I took one of the pots, and placed it by itself, making it communicate with the conductor, by means of a rod of metal. From the 3d of March to the 27th, I every hour, from morning to the evening, gave it an hundred turns with the wheel.

March 15th, in the evening, four grains of *electrified* rye rose, and early the next morning the rest appeared.

March 17, in the evening, two grains of the *non-electrified* rose, and six others appeared early the following day.

March 19, I measured the plants.

Two of the stalks from the *electrified* grain were six lines and a half high, four five lines, and two three lines.

Among the plants from the *non-electrified* grain, two were three lines high, others two lines and a half, and the shortest two lines.

March 26, two of the *electrified* rye plants were four inches and a half high; the greater part of them three inches and a half; and the smaller number two inches eleven lines and a half.

Two of the *non-electrified* plants were three inches and a half; and the rest an inch ten lines and a half. *So that there was a great disproportion between the electrified and non-electrified grains of rye.*

NINTH EXPERIMENT.

March 30. I sowed, in two pots, as much LETTUCE SEED as I could take up between my finger and thumb. I covered them with an equal quantity of mould; after which, I fixed on one of them, and electrified it in the following manner. I insulated it by means of a cake of pitch, a rod of metal descending from the conductor rested upon the vase. I electrified it every hour, with three or four hundred turns of the wheel, and continued this process until April 8th.

April 4th, between five and six o'clock in the morning, the plants came up in the *electrified* pot; and at a quarter after five in the afternoon those in the *non-electrified* pot did the same.

April 8th, at six in the evening, I measured their respective heights.

The electrified Lettuce taken from the top of the stalk to the root.

	Lines.
The highest	21
The greatest number	19
The lesser number	16

The non-electrified Lettuce taken from the top of the stalk to the root.

	Lines.
The highest	18
The greatest number	15
The lesser number	12

Having accomplished this comparison, I next drew out of the ground, just as they happened to stand, six plants of the *electrified* lettuce, with as many of the *non-electrified*, and the result from measurement was as follows:

Length of the electrified Lettuce, taken from where the root and stem join to the extremity of the root.

	Lines.
First	10
Second	18
Third	17
Fourth	15
Fifth	12
Sixth	12

Length of the non-electrified Lettuce, taken from where the root and stem join to the extremity of the root.

	Lines.
First	7
Second	16
Third	13
Fourth	12
Fifth	10
Sixth	8

TENTH EXPERIMENT.

From April 21st, at six o'clock in the morning, until six o'clock in the evening of the 23d, I electrified some grains of LETTUCE from six o'clock in the morning till nine at night, recharging the *magic table* every hour, and sometimes every half hour.

On the 23d, in the evening, I sowed these three seeds, and at the same time I sowed a like quantity of non-electrified seeds, in the same sort of mould, and taken out of the same paper; the two pots were alike placed, and so was the treatment, as in all my former experiments.

April 28th, by six o'clock in the evening, four plants from the *electrified* seeds came up, as did all the others during the course of the night.

April 29th, in the course of the evening, some of the plants from the *non-electrified* seeds appeared; and on the 30th, the rest did the same.

May 2d, I pulled up, with great precaution, from each of the pots several plants, as they chanced to stand, with a view to ascertain their respective dimensions. I observed by the first glance,

1st, That the stalks of the *electrified* plants were larger than those of the *non-electrified.*

2dly, That the roots of the *former* appeared longer and bolder; and I found them capable of bearing to be stretched out better than the others, for the *non-electrified* plants broke upon the smallest violence.

The electrified plants measured from the top to the root.

	Lines.
First	14
Second	13
Third	12
Fourth	12
Fifth	12
Sixth	10
Seventh	9½
Eighth	9
Ninth	10
Tenth	10
Eleventh	9
Twelfth	9½
Thirteenth	8
Fourteenth	7½
Fifteenth	6

The non-electrified plants measured from the top to the root.

	Lines.
First	12
Second	12
Third	11
Fourth	11
Fifth	10
Sixth	12
Seventh	9
Eighth	10
Ninth	11½
Tenth	10½
Eleventh	10
Twelfth	9½
Thirteenth	9
Fourteenth	12½
Fifteenth	6

The electrified plants measured from the top of the root to the extremity.

	Lines.
First	31½
Second	37½
Third	24½
Fourth	28½
Fifth	25
Sixth	29
Seventh	27
Eighth	28
Ninth	30
Tenth	30
Eleventh	25½
Twelfth	25½
Thirteenth	23
Fourteenth	28½
Fifteenth	22½

The non-electrified plants measured from the top of the root to the extremity.

	Lines.
First	18
Second	22
Third	23
Fourth	13
Fifth	26½
Sixth	24½
Seventh	29
Eighth	26½
Ninth	27½
Tenth	30
Eleventh	18
Twelfth	26
Thirteenth	18½
Fourteenth	18
Fifteenth	20

It results from this experiment, that in adding the length of these *electrified* plants, to that of their roots, the whole measure amounts to 557½ lines, which divided by 15, gives to each Lettuce 37 lines from the summit of the stalk to the extremity of the root.

In making the like calculation for the *non-electrified* Lettuce plants, the measures amounts only to 496½ lines, which likewise divided by 15, makes each plant 33 lines long.

There exists, therefore, a *difference* of three lines in each plant, between those *electrified* and the *non-electrified,* as proved by comparing the average amounts from the whole.

ELEVENTH EXPERIMENT.

After having taken from each vase the fifteen plants, as mentioned in the former experiment, I placed the vases in the shade, and purposely desisted from giving any water to the remaining plants in order to make an observation of another kind.

May 4th. The *electrified* plants were in just as good a state, as when I had watered them for the last time, April 30th.

The *non-electrified* had suffered exceedingly.

May 6th. The *electrified* Lettuces still retained a fine verdure, but the stalks began to bend down a little.

The *non-electrified* plants were faded, and drooped down on the ground.

May 8th, the *electrified* plants lost a little of their verdure, and the stalks were more bent.

The *non-electrified* plants were become yellow, the stalks white, and quite bent down upon the ground.

May 10th, the *non-electrified* plants were totally dead.

It was May 15th, before the *electrified* plants had completely withered.

TWELFTH EXPERIMENT.

May 7th, I electrified some Mustard Seeds, in doing of which I observed the following process:

I took two pieces of cork, to which I gave three lines in thickness, an inch and three lines in breadth, by two inches long; I then covered the superficial parts of these corks with some blotting paper that I had moistened, after which I put each piece of cork into a small vase, filled with water, and sowed about sixty seeds of MUSTARD on each of them.

This vase I electrified from that day to the end of the term, when the experiment was finished; and that from seven in the morning until ten at night.

May 9th, at eight o'clock in the morning I perceived some of the *electrified* seeds had germinated.

At eleven in the morning some of those in the *non-electrified* vase had done the same.

May 10th, I counted twenty-eight of the *electrified* grains had opened.

Eighteen of the *non-electrified* only, had done the same.

In the evening there were thirty-two of the *former*; and only twenty-six of the *latter*.

May 11th, at six in the morning there was upon the cork, in the *electrified* vase, fifty-four grains that had unfolded themselves; and upon the cork in the *non-electrified* vase, the number in that state amounted only to thirty-four.

On that day I measured the plants in the vases.

Electrified Plants.	Lines.
Twenty	6 . . . 7
The rest	4 . . . 5

Non-electrified Plants.	Lines.
Twenty	4 . . . 4½
The rest	4 . . . 3½

To these most conclusive Experiments in favour of electricity, I shall add but one, taken from the Abbé Bartholon.

THIRTEENTH EXPERIMENT.

AFTER having recorded upwards of fifty experiments, conducted at different seasons, and repeated through different years, all in favour of electricity, the Abbé relates the following, which was made by electrifying the *water* in which he steeped some seeds.

For this purpose I employed, says this able Experimentalist, five small pots of Dutch-ware, each of which I filled with water, and put into it but one kind of seed.

A coating of tin-foil was attached, both inside and outside, to form the electric communication, and the opening of each vase was shut with a cork, carefully varnished.

These five vases were afterwards put into an electric jar, which I had arranged as an *electric magazine,* and its orifice was enclosed by a large cork, covered over its whole surface with sealing-wax: and this cork was bored in the middle to receive a glass hollow tube, which descended to the bottom of the jar. The whole was afterwards varnished with green wax.

This apparatus was *electrified* for two days, with the exception of the nights. After the second day, the seeds were sown in the open ground in the same part of the garden, in little squares, divided each into two parts, A and B, for the seeds, which were *electrified,* and for those not so. Precaution was taken that every circumstance should resemble: hence the seeds were taken out of the same bag, these were shaken together, before they were taken out, and divided into two parcels, and they were put into similar pots, but placed out of the electric communication. Of each sort ten grains were sown. I observed in the pots marked,

A. The LUPINS *electrified* opened the ground on the *fifth* day after being sown, about two o'clock, and by seven o'clock seven of the same seeds began to appear, the cotyledons becoming visible. On the *sixth* day the remainder appeared like the rest in the morning. On the *seventh* day, the cotyledons were more open, and separated, and discovered the leaves of the plume. By the *eighth* day, these leaves were progressively developed, and gradually increased in size.

B. The LUPINS *not electrified,* did not appear before the *seventh* day in the morning, and then only three; in the evening two others shewed themselves. On the *eighth* day in the morning, four others, the remainder at twelve the same time. Their developement was progressive, but all the ten did not advance equally with the others.

Not to fatigue my readers with too much repetition of the same kind, I shall only observe, that from all these comparative experiments it appeared, that the VETCHES, BEANS, PEAS, &c. in the electrified water rose a day or two before those in the *simple* water, and were advanced accordingly.

The influence of *positive* or *vitreous electricity,*[*] says Dr. Darwin in his Phytologia, in forwarding the germination of plants and their growth, seems to be pretty well established; though some doubts on this head were raised by Dr. Ingenhousz.

The Abbé D'Ormey not only found various seeds to vegetate sooner, and to grow taller, which were put upon his insulated table, and supplied with electricity, as did the two Roziers; but also that silk-worms[†] began to spin much sooner, which were kept electrified, than those of the same hatch, which were kept in the same place and manner, except that they were not electrified.

The Abbé Bartholon, who had before written a tract on this subject, and proposed several ingenious methods for applying electricity to agriculture and gardening, has also repeated a numerous set of experiments, and shews that *natural electricity,* as well as the *artificial,* increases the growth of plants, and the germination of seeds, and opposes Dr. Ingenhousz by very numerous and conclusive facts. Vide Journal de Physique, par Rozier, tom. XXXV. p. 270, and p. 401.

FOURTEENTH EXPERIMENT.

MY friend, Mr. D. Bilsbourne, continues Dr. Darwin, in June 1797, sowed some MUSTARD seeds in four garden pots at Mr. Hartop's at Dalby Hall in Leicestershire. He subjected one of these to *positive* or *vitreous electricity,* and another *negative* or *resinous electricity,*[‡] and observed that the seeds in the pot subjected to the *negative* or *resinous electricity* germinated a day before those in the two pots, which were *not electrified,* but otherwise exposed to some circumstances.

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[*] Vide Note ‡, p. 157.

[†] Acard of Berlin raised the eggs of silk-worms by means of the electric fluid, as also those from the hen, (vide Bonnet's Contemplation of Nature) and Spalanzani found that the fecundated spawn of the frog was in the same manner vivified by the electric fluid, and this philosopher observes, "they grew faster than those that were not electrified," an event which exactly corresponds with the acceleration of vegetation occasioned by the electric fluid. (See Dissertation II.)

[‡] Vide Dr. Darwin's Temple of Nature, or Origin of Society, p. 46, where will be found a long dissertation on the subject of these two electricities.

It appears, says the celebrated Cavallo, from the observations which have been made on the electricity of the atmosphere, that Nature makes great use of this fluid in promoting vegetation.

1. In the spring, when seeds begin to sprout, then temporary electrical clouds appear, and pour forth electric rain. The electricity of the clouds and rain continues to increase, till that part of the autumn in which the last fruits are gathered.

2. It is this fluid which collects the vapours, forms clouds, and is then employed to disorder and dissipate them in rain. It gives fire to common moisture, by the help of which it actuates and animates vegetation.

3. From this principle may be explained the old proverb, " that no watering gives the country so smiling a look as rain." The clouds of rain by extending their electric atmosphere to the plants, dispose the pores of the latter to receive with greater facility the water which is impregnated with this penetrating and diluting fluid.

Ventinat in his *Tableau du regne vegetal,* vol. i. in confirmation of this doctrine, says, notwithstanding the ingenious manner in which Dr. Ingenhousz* has endeavoured to overthrow the belief of the importance of electricity to vegetation, the well known increase of some plants after thunder-storms leaves us no longer in doubt on this subject. Dauberton mentions, that he

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* One of the arguments used by Dr. Ingenhousz against the beneficial effects of electricity on vegetation, is the well known rapid growth of plants in Egypt, where there seldom appears any rain. It has been argued in many places of this work, that Nature is seldom prodigal; and where less stimulation was wanted, there the different operating agents were not found so abundant. Heat and moisture sufficiently combine here to produce this rapid increase, and the plentiful dews, which fall every evening, would at any rate compensate for the loss of electric showers. I shall take this opportunity of calling the attention of my readers to a very singular production of the electric fluid, which is frequent in the sultry regions adjoining to the Egyptian shores. Bruce, the discoverer of the source of the Nile, thus describes this wonderful natural phænomenon. " In that vast expanse of desert, from the west to the north-west of us, we saw," says this traveller, " many prodigious *moving pillars of sand* at different distances, at times darting forward with great celerity, at others, stalking on with a majestic slowness; at intervals we thought they were coming in a very few minutes to overwhelm us; and flying particles of sand did actually more than once reach us. Again they would retreat, and diminishing by degrees, at length disappear. The tops of these pillars seemed to reach the very clouds. Sometimes a separation would take place, and the pillars would become disjointed, when presently they dispersed in air, and appeared no more. About noon they began to advance with considerable swiftness upon us, the wind being very strong at north: eleven of them ranged along-side of us, probably, at the distance of three miles. Their greatest diameter, as far as one could judge, from sight, might be about ten feet. These appeared at intervals during the whole of the day. As the evening was drawing in, and the sun was setting, they produced a superb Temple, and his rays shining through

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them, gave them all the appearance of *pillars of fire.* They now approached nearer to us, within two miles. It was in vain to think of flying; the swiftest horse, or fastest sailing ship, could be of no use to carry us out of this danger; this persuasion rivetted us to the spot where we were to sleep, creating an impression on the mind, to which I can find no name, though surely one ingredient in it was fear, with a considerable deal of wonder and astonishment."

Water-spouts at sea, like *whirlwinds* by land, known also in hot climates, arise likewise from the electric fluid. These commonly begin with a cloud, which appears very small, and which mariners call the squall, which augments in a little time into an enormous cloud of a cylindrical form, or that of a reversed cone, and produces a noise like an agitated sea, sometimes emitting thunder and lightning, and also large quantities of rain or hail, sufficient to inundate large vessels, overset trees and houses, and every thing which opposes its violent impetuosity.

Tournefort thus describes this strange phænomenon. " The first I ever saw," says this traveller, " was about a musket-shot from our ship. There we perceived the water begin to boil, and to rise about a foot above its level. The water was agitated and whitish; and above its surface there seemed to stand a smoke, such as might be imagined to come from wet straw before it begins to blaze. It made a sort of a murmuring sound, like that of a torrent heard at a distance, mixed, at the same time, with an hissing noise, like that of a serpent: shortly after we perceived a column of this smoke rise up to the clouds, at the same time whirling about with great rapidity. It appeared to be as thick as one's finger; and the former sound still continued. When this disappeared, after lasting for about eight minutes, upon turning to the opposite quarter of the sky, we perceived another, which began in the manner of the former; presently after a third appeared in the west; and instantly beside it still another arose. The most distant of these three could not be above a musket-shot from the ship. They all continued like so many heaps of wet straw set on fire, that continued to smoke, and to make the same noise as before. We soon after perceived each, with its respective canal, mounting up in the clouds, and spreading, where it touched the cloud, like the mouth of a trumpet. These canals were of a whitish colour, and so tinged, as I suppose, by the water which was contained in them; for, previous to this, they were apparently empty, and of the colour of transparent glass. These canals were not straight, but bent in some parts, and far from being perpendicular, but rising in their clouds with a very inclined ascent. But what is very particular, the cloud to which one of them was pointed happening to be driven by the wind, the spout still continued to follow its motion, without being broken; and passing behind one of the others, the spouts crossed each other, in the form of a St. Andrew's cross. In the beginning they were all about as thick as one's finger, except at the top, where they were broader, and two of them disappeared; but shortly after, the last of the three increased considerably; and its canal, which was at first so small, soon became as thick as a man's arm, then as his leg, and at last thicker than his whole body. We saw distinctly, through this transparent body, the water, which rose up with a kind of spiral motion; and it sometimes diminished a little of its thickness, and again resumed the same; sometimes widening at top, and sometimes at bottom; exactly resembling a gut filled with water, pressed with the fingers, to make the fluid rise, or fall; and I am well convinced, that this alteration in the spout was caused by the wind, which pressed the cloud, and impelled it to give up its contents. After some time its bulk was so diminished as to be no thicker than a man's arm again; and thus, swelling and diminishing, it at last became very small. In the end, I observed the sea which was raised about it to resume its level by degrees, and the end of the canal that touched it to become as small as if it had been tied round with a cord; and this continued till the light, striking through the cloud, took away the view. I still, however, continued to look, expecting that its parts would join again, as I had before seen in one of the others, in which the spout was more than once broken, and yet again came together; but I was disappointed, for the spout appeared no more."

is acquainted with a gardener, who always washes off the electric showers by a plentiful dilution with common water to hinder his lettuces from running to seed, which otherwise they would do. A practical hint derived from one not conscious of theory.

DEWS advance vegetation from this source.

Electricity augments the natural evaporation of fluids, and especially of those fluids which are most subject to evaporation of themselves; and it has also a great effect on fluids, when the vessels containing them are non-electrics. If a humid body, a sponge for instance, be placed upon a conductor positively electrified, the evaporation will go on much more rapidly, and it will be much sooner dry, than a similar body differently circumstanced.

When water is passing out of small tubes in a continued stream, if these be electrified, the whole escapes in fine sprays, and evaporates in the form of dew.

Signor Volta has observed, that water in a state of evaporation, as when thrown upon hot coals, produces always negative electricity.

There are many operations of Nature constantly carrying on, which escape the ordinary observations of mankind, but when known excite the highest sense of astonishment.

The evaporation of water, and the fall of dew is of this nature.

Who could have conjectured, says the learned Bishop of Landaff,* that an acre of ground, even after having been parched by the heat of the sun in summer, dispersed into the air above 1600 gallons of water in the space of twelve of the hottest hours of the day? No vapour is seen to ascend, and we little suppose that in the hottest part of the day, more usually does ascend than in any other. The experiment from which I draw this conclusion, is so easy to be made, that every one may satisfy himself of the truth of it.

FIRST EXPERIMENT.

ON the 2d of June, 1779, when the sun shone bright and hot, I put a large drinking glass, with its mouth downwards, upon a grass-plat which was mown close; there had been no rain for above a month, and the grass was become brown; in less than two minutes the inside of the glass was clouded with a vapour, and in half an hour drops of water began to trickle down its inside, in various places. This experiment was repeated several times with the same success. That I might accurately estimate the quantity, thus raised, in any certain portion of time, I measured the area of the mouth of the glass, and found it to be twenty square inches: there are 1296 square inches in a square yard, and 4840 square yards in a statute acre; hence, if we can find the means of measuring the quantity of vapour raised from twenty square inches of earth, suppose in one quarter of an hour, it will be an easy matter to calculate the quantity which would be raised with the same degree of heat, from an acre in twelve hours. The method I took to measure the quantity of vapour, was not perhaps the most accurate which might be thought of, but it was simple and easy to be practised: when the glass had stood on the grass-plat one quarter of an hour, and had collected a quantity of vapour, I wiped its inside with a piece of muslin, the weight of which had been previously taken; as soon as the glass was wiped dry, the muslin was weighed again, its increase of weight shewed the quantity of vapour which had been collected. The medium increase of weight, from several experiments made on the same day, between twelve and three o'clock, was six grains collected in one quarter of an hour, from twenty square inches of earth. If the reader takes the trouble to make the calculation, he will find that above 1600 gallons, reckoning eight pints to a gallon, and estimating the weight of a pint of water at one pound avoirdupois, or 7000 grains troy weight, would be raised, at the rate here mentioned, from an acre of ground in 24 hours.

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* Vide Chemical Essays, vol. iii.

The immense quantity of exhalation from the seas surrounding our globe is still more astonishing. Dr. Hally, by observing the quantity evaporated from a vessel full of water of the same degree of saltness with that of the ocean, calculated, that the quantity exhaled from the *Mediterranean Sea* alone, in one summer's day, there being little wind, amounted to 5,280,000,000 tons of water.

SECOND EXPERIMENT.

It may easily be conceived, that the quantity thus elevated will be greater when the ground has been well soaked with rain, provided the heat be the same; I did not happen to mark the heat of the ground when I made the fore-mentioned experiment; the two following are more circumstantial: the ground had been wetted the day before I made them by a thunder-shower, the heat of the earth, at the time of making them, estimated by a thermometer laid on the grass, was ninety-six degrees; one experiment gave 1973 gallons from an acre in twelve hours, the other gave 1905. Another experiment made, when there had been no rain for a week, and the heat of the earth was 110 degrees, gave after the rate of 2800 gallons from an acre in twelve hours.

The quantity of water which was condensed on the inside of the glass, I found to be accurately proportionable to the time during which it stood on the grass; for in one experiment six grains were collected in ten minutes, and in another fifteen grains were collected in twenty-five minutes; now the proportion of six to ten is the same as that of fifteen to twenty-five.

In order to see whether the copious vapour collected by the glass was owing to the natural perspiration of the grass, or to a kind of mechanical distillation from the body of the earth, I put the glass upon a footpath which was dry, and had no grass growing upon it, the vapour rose from the footpath as well as from the grass, but not so abundantly.

THIRD EXPERIMENT.

Upon the same grass-plat, and contiguous to the glass used in these experiments, I placed a silver cup, with its mouth downwards, of a shape similar to that of the glass, and nearly of the same dimensions; but I could never observe that its inside had collected the least particle of vapour, though I frequently let it stand on the grass for half an hour or more.

FOURTH EXPERIMENT.

By means of a little bees wax, I fastened an half crown very near, but not quite contiguous, to the side of the glass, and setting the glass, with its mouth downwards, on the grass, it presently became covered with vapour, except that part of it which was near to the half crown. Not only the half crown itself was free from vapour, but it had hindered any from settling on the glass which was near it, for there was a little ring of glass surrounding the half crown to the distance of one-fourth of an inch which was quite dry, as well as that part of the glass which was immediately under the half crown; it seemed as if the silver had repelled the water to that distance.

SIXTH EXPERIMENT.

A LARGE red wafer had the same effect as the half crown; it was neither wetted itself, nor was the ring of glass contiguous to it wetted. A circle of white paper produced the same effect, so did several other substances, which it would be tedious to enumerate.

These phenomena, respecting the different disposition of different bodies to attract the rising vapour, are similar to what others have taken notice of concerning the *falling* of *dew*, and are, probably, to be explained upon the same principles.

SEVENTH EXPERIMENT.

MUSCHENBROEK placed on the leaden terrace of the Observatory at Utrecht, vessels of glass, china, varnished wood, polished brass, and pewter: he found that in the course of a night the glass, china, and varnished wood, had collected a great abundance of dew, but that not a drop had fallen on any of the polished metals. M. du Fay likewise exposed to the air, when the dew was falling, two large funnels, one made of glass, the other of polished pewter; the necks of the funnels being inserted into vessels proper to retain any moisture which might be collected by them; he sometimes found in the morning that the vessel under the glass funnel contained an ounce or more of water, but he never observed so much as a single drop in the other.

CONCLUSION.

HENCE the effects of dews, and of thunder showers, confirm yet more the prevailing opinion, that electricity accelerates the evolution and growth of seeds.

SECT. XX.

ON DARKNESS AS FAVOURABLE TO GERMINATION.

> Even the weak *Embryo,* ere to life it breaks,
> From HIS high pow'r its slender texture takes;
> While in HIS book the various parts inroll'd,
> Increasing, own eternal *Wisdom's* mould.
>
> SMART.

THAT light and heat, are distinct bodies though often conjoined, was known to the Honourable and Illustrious Mr. Boyle.

In general, a very considerable degree of heat is requisite to the emission of light from any body; but there are several exceptions to this, especially in light proceeding from putrescent substances and phosphorus, together with that of luminous animals, and other similar appearances. Light proceeding from putrescent animal and vegetable substances, as well as from glow-worms, is mentioned by Aristotle. Thomas Bartholin mentions four kinds of luminous insects, two with wings, and two without; but in hot climates travellers say they are found in much greater numbers, and of different species. Columna, an industrious naturalist, observes, that their light is not extinguished immediately upon the death of these animals.

The first distinct account that we meet with of light proceeding from putrescent animal flesh is that which is given by Fabricius ab Aquapendente; who says, that when three Roman youths, residing at Padua, had bought a lamb, and had eaten part of it on Easter day 1592, several pieces of the remainder, which they kept till the day following, shone like so many candles when they were casually viewed in the dark. Part of this luminous flesh was immediately sent to Aquapendente, who was professor of anatomy in that city. He observed that both the lean and the fat of this meat shone with a whitish kind of light; and also took notice, that some pieces of kid's flesh, which had happened to have lain in contact with it, was luminous, as well as the fingers and other parts of the bodies of those persons who touched it. Those parts, he observed shone the most which were soft to the touch, and seemed to be transparent in candle light; but where the flesh was thick and solid, or where a bone was near the outside, it did not shine.

After this appearance, we find no account of any other similar to it, before that which was observed by Bartholin, and of which he gives a very pompous description in his ingenious treatise already quoted. This happened at Montpelier in 1641, when a poor old woman had bought a piece of flesh in the market, intending to make use of it the day following. But happening not to be able to sleep well that night, and her bed and pantry being in the same room, she observed so much light come from the flesh as to illuminate all the place where it hung. A part of this luminous flesh was carried as a curiosity to Henry Bourbon, duke of Condé, the governor of the place, who viewed it for several hours with the greatest astonishment.

This light was observed to be whitish; and not to cover the whole surface of the flesh, but certain parts only, as if gems of unequal splendor had been scattered over it. This flesh was kept till it began to putrify, when the light vanished; which, as some religious people fancied, it did in the form of a cross.

It is natural to expect, that the almost universal experimental philosopher Mr. Boyle should try the effect of his air-pump upon these luminous substances. Accordingly we find that he did not fail to do it; when he presently found that the light of rotten wood was extinguished *in vacuo*, and revived again on the admission of air, even after a long continuance *in vacuo*; but the destruction of this light was not so complete immediately upon exhausting the receiver, as some little time afterwards. He could not perceive, however, that the light of rotten wood was increased in condensed air; but this he imagined might arise from his not being able to judge very well of the degree of light, through so thick and cloudy a glass-vessel as he then made use of; but found that the light of a shining fish, which was put into a condensing engine before the Royal Society, in 1668, was rendered more vivid by that means. The principal of Mr. Boyle's experiments were made in October 1667.

This philosopher attended to a great variety of circumstances relating to this curious phenomenon. Among other things he observed, that change of air was not necessary to the maintenance of this light; for it continued a long time when a piece of the wood was put into a very small glass hermetically sealed, and it made no difference when this tube which contained the wood was put into an exhausted receiver. This he also observed with respect to a luminous fish, which he put into water, and placed in the same circumstances. He also found that the light of the shining fishes had other properties in common with that of shining wood; but the latter, he says, was presently quenched with water, spirits of wine, a great variety of saline mixtures, and other fluids. Water, however, did not quench all the light of some shining veal on which he tried it, though spirit of wine destroyed its virtue presently.

Mr. Boyle's observation of light proceeding from fresh meat was quite casual. On the 15th of February 1662, one of his servants was greatly alarmed with the shining of some veal, which had been kept a few days, but had no bad smell, and was in a state very proper for use, The servant immediately made his master acquainted with this extraordinary appearance; and though he was then in bed, he ordered it to be immediately brought to him, and he examined it with the greatest attention. Suspecting that the state of the atmosphere had some share in the production of this phenomenon, he takes notice, after describing the appearance, that the wind was south-west and blustering, the air hot for the season, the moon was past its last quarter, and the mercury in the barometer was at 29^3 inches.

Mr. Boyle was often disappointed in his experiments on shining fishes; finding that they did not always shine, in the very same circumstances, as far as he could judge, with others which had shined before. At one time that they failed to shine, according to his expectations, he observed that the weather was variable, and not without some days of frost and snow. In general he made use of whitings, finding them the fittest for his purpose. In a discourse, however, upon this subject at the Royal Society in 1681, it was asserted that of all fishy substances, the eggs of lobsters, after they had been boiled, shone the brightest. Olig. Jacobœus observes, that upon opening a sea-polypus, it was so luminous, as to startle several persons who saw it; and he says that the more putrid the fish was, the more luminous it grew. The nails also, and the fingers of the persons who touched it, became luminous; and the black liquor which issued from the animal, and which is its bile, shone also, but with a more faint light.

Mr. Boyle draws a very minute comparison between the light of burning coals and that of shining wood or fish, showing in what particulars they agree, and in what they differ. Among other things he observes, that extreme cold extinguishes the light of shining wood, as appeared when a piece of it was put into a glass tube, and held in a frigorific mixture. He also found that rotten wood did not waste itself by shining, and that the application of a thermometer to it did not discover the least degree of heat.

There is a remarkable shell-fish called Pholas, which forms for itself holes in various kinds of stone, &c. That this fish is luminous, was noticed by Pliny; who observes, it shines in the mouth of the person who eats it, and if it touch his hands or cloaths, makes them luminous. He also says that the light depends upon its moisture. The light of this fish has furnished matter for various observations and experiments to M. Reaumur, and the Bolognian academicians, especially Beccarius, who took so much pains with the subject of phosphoric light.

M. Reaumur observes, that, whereas other fishes give light when they tend to putrescence, this is more luminous in proportion to its being fresh; that when they are dried, their light will revive if they be moistened either with fresh or salt water, but that brandy immediately extinguishes it. He endeavoured to make this light permanent, but none of his schemes succeeded.

The attention of the Bolognian academicians was engaged to this subject by M. F. Marsilius, in 1724, who brought a number of these fishes, and the stones in which they were inclosed, to Bologna, on purpose for their examination.

Beccarius observed, that though this fish ceased to shine of itself when it became putrid; yet that in its most putrid state, it would shine, and make the water in which it was immersed luminous, when it was agitated. Galeatius and Montius found, that wine or vinegar extinguished this light; that in common oil it continued some days; but in rectified spirit of wine or urine, hardly a minute.

In order to observe in what manner this light was affected by different degrees of heat, they made use of a Reaumur's thermometer, and found that water rendered luminous by these fishes increased in light till the heat arrived to 45 degrees; but that it then became suddenly extinct and could not be revived.

In the experiments of Beccarius, a solution of sea-salt increased the light of the luminous water, a solution of nitre did not increase it quite so much.

Sal ammoniac diminished it a little, oil of tartar *per deliquium* nearly extinguished it, and the acids entirely. This water poured upon fresh calcined gypsum, rock chrystal, ceruss, or sugar, became more luminous. He also tried the effects of it when poured upon various other substances, but there was nothing very remarkable in them. Afterwards, using luminous milk, he found that oil of vitriol extinguished the light, but that oil of tartar increased it.

This gentleman had the curiosity to try how differently coloured substances were affected by this kind of light; and having, for this purpose, dipped several ribbons in it, the white came out the brightest, next to this was the yellow, and then the green; the other colours could hardly be perceived. It was not, however, any particular colour, but only light that was perceived in this case. He then dipped boards painted with the different colours, and also glass tubes, filled with substances of the different colours, in water rendered luminous by the fishes. In both these cases the red was hardly visible, the yellow was the brightest, and the violet the dullest. But on the boards the blue was nearly equal to the yellow, and the green more languid; whereas in the glasses, the blue was inferior to the green.

Of all liquors into which he put the pholades, milk was rendered the most luminous. A single pholas made seven ounces of milk so luminous, that the faces of persons might be distinguished by it, and it looked as if it was transparent.

Air appeared to be necessary to this light; for when Beccarius put the luminous milk into glass tubes, no agitation would make it shine, unless bubbles of air were mixed with it. Also Montius and Galeatius found, that, in an exhausted receiver, the pholas lost its light, but the water was sometimes made more luminous; which they ascribed to the rising of bubbles of air through it.

Beccarius, as well as Reaumur, had many schemes to render the light of these pholades permanent. For this purpose he kneaded the juice into a kind of paste, with flour, and found that it would give light when it was immersed in warm water; but it answered best to preserve the fish in honey. In any other method of preservation, the property of becoming luminous would not continue longer than six months, but in honey it lasted above a year; and then it would, when plunged in warm water, give as much light as ever it had done before.

Similar, in some respects, to those observations on the light of the pholas, was that which was observed to proceed from wood which was moist, but not in a putrid state, which was very conspicuous in the dark.

That the sea is sometimes luminous, especially when it is put in motion by the dashing of oars and the beating of it against a ship, has been observed with admiration by a great number of persons. Mr. Boyle, after reciting all the circumstances of this appearance, as far as he could collect them from the accounts of navigators; as its being extended as far as the eye could reach, and at other times being visible only when the water was dashed against some other body; that in some seas this phenomenon is accompanied by some particular winds, but not in others; and that sometimes one part of the sea will be luminous, when another part, not far from it, will not be so; concludes with saying, that he could not help suspecting that these odd phenomena, belonging to great masses of water, were in some measure owing to some cosmical law or custom of the terrestrial globe, or at least of the planetary vortex.

Some curious observations on the shining of some fishes, and the pickle in which they were immersed, were made by Dr. Beal, in 1765; and had they been properly attended to and pursued, might have led to a discovery of the cause of this appearance. Having put some boiled mackerel, together with salt and sweet herbs; when the cook was, some time after, stirring it, in order to take out some of the fishes, she observed, that, at the first motion, the water was very luminous; and that the fish shining through the water added much to the light which the water yielded. The water was of itself thick and blackish, rather than any other colour; and yet it shined on being stirred, and at the same time the fishes appeared more luminous than the water. Wherever the drops of this water, after it had been stirred, fell to the ground, they shined; and the children in the family diverted themselves with taking the drops, which were as broad as a penny, and running with them about the house. The cook observed, that, when she turned up that side of the fish that was lowest, no light came from it; and that, when the water had settled for some time, it did not shine at all. The day following, the water gave but little light, and only after a brisk agitation, though the fishes continued to shine, as well from the inside as the outside, and especially about the throat, and such places as seemed to have been a little broken in the boiling.

When in the light of the sun, he examined, with a microscope, a small piece of a fish which had shined very much the night before, he found nothing remarkable on its surface, except that he thought he perceived what he calls a *steam,* rather dark than luminous, arising like a very small dust from the fish, and here and there a very small and almost imperceptible sparkle. Of the sparkles he had no doubt; but he thought it possible that the steam might be a deception of the sight, or some dust in the air.

Finding the fish to be quite dry, he moistened it with his spittle; and then observed that it gave a little light, though but for a short time. The fish at that time was not fetid, nor yet insipid to the best discerning palate. Two of the fishes he kept two or three days longer for farther trial: but the weather being very hot, they became fetid; and, contrary to his expectations, there was no more light produced either by the agitation of the water or in the fish.

Father Bourzes, in his voyage to the Indies in 1704, took particular notice of the luminous appearance of the sea. The light was sometimes so great, that he could easily read the title of a book by it, though he was nine or ten feet from the surface of the water. Sometimes he could easily distinguish, in the wake of the ship, the particles that were luminous from those that were not; and they appeared not to be all of the same figure. Some of them were like points of light, and others such as stars appear to the naked eye. Some of them were like globes, of a line or two diameter; and others as big as one's head. Sometimes they formed themselves into squares of three or four inches long, and one or two broad. Sometimes all these different figures were visible at the same time; and sometimes there were what he calls *vortices* of light, which at one particular time appeared and disappeared immediately like flashes of lightning.

Nor did only the wake of the ship produce this light, but fishes also, in swimming, left so luminous a track behind them, that both their size and species might be distinguished by it. When he took some of the water out the sea and stirred it ever so little with his hand, in the dark, he always saw in it an infinite number of bright particles; and he had the same appearance whenever he dipped a piece of linen in the sea, and wrung it in a dark place, even though it was half dry; and he observed that when the particles fell upon any thing that was solid, it would continue shining for some hours together.

After mentioning several circumstances which did not contribute to this appearance, this Father observes, that it depends very much upon the *quality of the water*; and he was pretty sure that this light is the greatest when the water is fattest, and fullest of foam. For in the main sea, he says, the water is not every where equally pure; and that sometimes if linen be dipped in the sea, it is clammy when it is drawn up again: and he often observed, that when the wake of the ship was the brightest, the water was the most fat and glutinous, and that linen moistened with it produced a great deal of light, if it was stirred or moved briskly. Besides, in some parts of the sea, he saw a substance like saw-dust, sometimes red and sometimes yellow; and when he drew up the water in those places, it was always viscous and glutinous. The sailors told him, that it was the spawn of whales; that there are great quantities of it in the north; and that sometimes, in the night, they appeared all over of a bright light, without being put in motion by any vessel or fish passing by them.

As a confirmation of this conjecture, that the more glutinous the sea-water is, the more it is disposed to become luminous, he observes, that one day they took a fish which was called a *bonite,* the inside of the mouth of which was so luminous, that without any other light, he could read the same characters which he had before read by the light of the wake of the ship; and the mouth of this fish was full of viscous matter, which, when it was rubbed upon a piece of wood, made it immediately all over luminous; though, when the moisture was dried up, the light was extinguished.

The abbé Nollet was much struck with the luminousness of the sea when at Venice in 1749; and, after taking a great deal of pains to ascertain the circumstances of it, concluded that it was occasioned by a shining insect; and having examined the water very often, he at length did find a small insect, which he particularly describes, and to which he attributes the light. The same hypothesis had also occurred to M. Vianelli, professor of medicine in Chioggia near Venice; and both he and M. Grizellini, a physician in Venice, have given drawings of the insects from which they imagined this light to proceed.

The abbé was the more confirmed in his hypothesis, by observing, some time after, the motion of some luminous particles in the sea. For, going into the water, and keeping his head just above the surface, he saw them dart from the bottom, which was covered with weeds, to the top, in a manner which he thought very much resembled the motions of insects; though, when he endeavoured to catch them, he only found luminous spots upon his handkerchief, which were enlarged when he pressed them with his finger.

The dissimilarity of light and heat is evinced by this simple circumstance; that as light gives no heat to transparent bodies, which the emanations from a fire do, there is reason to believe them to be different fluids. Thus when smoke is blown near the focus of a large burning glass, it does not ascend; which shews that the air is not heated and rarefied by it; though it would burn or vitrify in an instant any opake body which might be opposed to it; but the emanations of heat from a fire soon rarefy and warm the air in its vicinity, causing it to ascend, as may be seen by a spiral card-vann placed over a chimney-piece, and which is agreeably seen in the use of the new glass fire-screens of Parisian invention, which placed before a parlour fire permit the rays of light to pass, but intercept the emanations of fluid heat.

For the better imbibing of caloric, or the matter of heat, the vegetable mould is of a dark colour nearly black, and that this is most favourable for that intention is shewn by the following experiment.

EXPERIMENT.

During the hot weather, which we had in the latter end of June and the beginning of July, 1772, I made an experiment at Cambridge, which I then thought no more of, but which an accident brought to my mind again; and I now venture to relate an account of it, in hopes that some philosophical friend will take the trouble of prosecuting it. I exposed, says the Bishop of Landaff, the bulb of an excellent thermometer to the direct rays of the sun, when the sky was perfectly free from clouds; the mercury rose 108° of Fahrenheit's scale, and continued stationary. A fancy struck me, to give the bulb a black covering; this was easily effected by a camel's hair pencil and Indian ink; the mercury fell a few degrees during the application of the coating, and the evaporation of the water; but presently after rose to 118°, or 10° in consequence of the black coat with which I had covered that part of the bulb which was exposed to the sun.

The air, which is a bad conductor of electricity, is known also to be a bad conductor of heat; and thence prevents the heat acquired from the sun's rays by the earth's surface from being too soon dissipated, in the same manner as a blanket, which may be considered as a sponge filled with air, prevents the escape of heat from the person wrapped in it.

That heat is indispensible towards germination is known to every one. During the cold winter, the vessels are closed, the fluids are torpid, and these are only to be excited in the proper season when the " penetrative sun" rouses the embryo from its slumber into animated life. But, on the contary, light is unfavourable, as depriving the seeds of the oxygen, so necessary to stimulate its first actions.

The fine experiments of Scheele and Berthollet have shewn that the absence or presence of light has a surprising effect upon the result of chemical experiments.

Light disengages oxygen air from the nitric acid, the oxygenated marine acid, &c. It reduces the oxyds, or calces of gold, silver, &c. It changes the nature of oxygenated muriates, according to the observations of Berthollet.

Hence it may likewise be supposed to deprive the seed of what rouses it into action, namely its oxygen.

That light impedes germination was first shewn by Dr. Ingenhousz.

FIRST EXPERIMENT.

I PLACED, says this admirable philosopher, in the open air exposed to the sun, 60 seeds of mustard, placed equally distant, on an island of cork, floating on a glass vessel, full of water, and the sides of the glass were left exposed.

SECOND EXPERIMENT.

IN the second, the apparatus was placed in a window in a room. The window shut.

THIRD EXPERIMENT.

IN a similar apparatus, the glass was covered with black paper.

FOURTH EXPERIMENT.

In a fourth, the apparatus was put in the room, in the shade.

FIFTH EXPERIMENT.

In a fifth, wholly excluded from the light.

RESULT.

In twenty-four hours some grains had already begun to push out the radicle, in the third, fourth, and fifth experiments.

In forty-eight hours the radicles appeared in the second apparatus.

On the third day, all had radical leaves, except the first.

On the fourth day, the radicle in the first appeared in a few seeds only; all the others were destroyed.

In experiment first, exposed to the full action of the sun the seeds might seem to have suffered from a too great degree of heat; but the seeds in the third apparatus had undergone a greater degree of heat; for the first shewed 82 degrees of heat, the second was at 86, and the third at 92 degrees.

They each advanced exactly in proportion to the exclusion of light.

These experiments were so often repeated, and always with the same result, that there no longer remains any ground for doubt.

The abbé Bertholon suspected, that the quicker vegetation of seeds arose from the quantity of water being greater in the one case than the other. Senebier, to determine this point, made the following experiment.

SIXTH EXPERIMENT.

He placed pease, beans, and french beans, upon sponges, which had imbibed an equal degree of water, inclosed in tin vessels of a determinate size, covered with cemented glass.

Some of these cases were painted in the inside, of a red colour. They were all exposed to the same influence of the sun.

The water which might evaporate from the sponges was prevented from escaping, so that, upon this ground, there could be no source of deception.

But the germination proceeded much more rapidly in the darkened cages, than in those which were exposed to the influence of the light.

SEVENTH EXPERIMENT.

In other cases in a darkened chamber, where an increased heat could not have excited the germination, as in those exposed to the sun, here the germination was even more rapid than in the other instances.

CONCLUSION.

Light therefore must be considered as unfavourable to germination.

SECT. XXI.

ON THE VITALITY OF SEEDS.

First, if you can, *celestial Guide!* disclose
From what fair fountain varied *life* arose,
Whence the fine nerve to move and feel assign'd,
Contractile fibre, and ethereal mind?—
" GOD, THE FIRST CAUSE!—*in this terrene abode*"
Young NATURE' cries, (who is the child of God)
" *From embryon births the changeful forms improve,*
" *Grow, as they live, and strengthen as they move!*"
DARWIN.

The Deity hath implanted the power of attraction into mineral bodies, and given life, or vitality, to the two other Kingdoms of Nature.

In what life consists is as much a mystery as attraction itself. When called into action we at once acknowledge this extraordinary principle, but when lying dormant, as in the seed, we feel at first loth to acknowledge it.

To exemplify what is meant by this principle when in a dormant state, the illustrious Haller, speaking of Mosses, says, " that they appear to possess the privilege almost of immortality, for after being dried in books, and kept in them for two or three hundred years, solely by being macerated in water, they are restored to their pristine life and vigour *, which experiments I repeated with some of the Mosses in the herbarium of the Bauhines."

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* I cannot forbear mentioning *here* some account of a small microscopical animal, which Lewenhoeck has named *rotifer* (wheel-polypus). All the observers, even the most modern ones, that have succeeded him, have believed that this animal has real wheels; but to be certain of the contrary, it is only necessary to place it betwixt two pieces of glass, and then observe it with an excellent microscope. It is a small gelatinous worm, commonly found in the earth or sand, collected by rain in the tops of houses. I have likewise found it in other earths, as well as in waters that have been some time stagnant, and more frequently again in those that have a very gentle current, and are filled

Thus the seeds of many plants retain their vital power for incalculable years, only requiring the agents of heat, moisture, and air, to put this principal into action, and make it self-evident to our senses.

Our ideas of life have been so much connected with organic bodies, and principally those endowed with visible action, that it requires a new bend to the mind, to make it conceive that these circumstances can be separable.

An organ is a peculiar construction of parts to answer some purpose, the operation of which may depend upon such a configuration, but mere organization can do nothing, even in mechanics it must still have something corresponding to the living principle, some power.

Brown, the Reformer of Medicine, calls life a forced state, and therefore makes life to consist of action, whereas sometimes it is quiescent, but susceptible of action from adapted stimuli, and of consequent alterations, both in the organization and modes of action.

Lamark entertains an opinion somewhat similar.

"Jusqu'au moment de la *germination,* toutes les parties d'une semence qui se trouve séparée de la plante-mère qui l'a produite, sont en quelque sorte dans un repos complet: les sucs qu'elle renferme y sont en quantité médiocre,

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with conferva and other aquatic plants. This worm is divided towards its head into two pretty large trunks, which appear like two wheels or stars, from the number of small, extremely sharp, and short branches that are attached to their circumference. These really appeared to Lewenhoeck to be wheels of a rare mechanism, and every one would judge the same, on seeing the creature put them in motion. But a more exact observation at length convinced me that they are not wheels, but composed of a quantity of small moveable arms, formed like pointed cones, and planted all round the two trunks. It lets fall these moveable arms or rays successively, and afterwards raises one after the other with so much celerity, that the eye fancies they are turning round like the spokes of a coach wheel, or rather, like the branches of a wheeled fire-work. It never moves these two wheels, except when it swims or wishes to eat, and these two states are invariably the shortest of its life. In swimming, it strikes the water with these arms or branches with great celerity, rests itself at different periods, and thus transports itself from one place to another. When it eats, it, on the contrary, fixes its tail in some substance, and afterwards turns its two wheels, giving such a motion to the water, that it directs the course of it towards its head, so that it presents to its mouth all the small corpuscles with which it is filled.

The Wheel-Polypus loses, like the moss, when dried, all appearance of life, but recovers the same when immersed in water. I have left it, says Fontana, by way of experiment, in a very dry soil, and exposed it, during the summer, to the whole heat of the sun, for the space of two years and an half. I afterwards returned it again into water, where at the end of two hours, it recovered life and motion. I put one of them on a piece of glass, which I exposed, during a whole summer, to the noon-day sun; it there became so dry, that it was like a piece of hardened glue. A few drops of water did not, however, fail to restore its motion and life.

Thus the microscopical eels that are found dry and withered in smutty wheat, recover motion and life as soon as they are wetted with a little water, and again become lifeless and dry, whenever they are no longer moistened. I have repeatedly assured myself of this with an extreme pleasure.

sans action, sans mouvement; et l'on peut conjecturer qu'il existe un equilibre parfait entre l'action et la reaction des diverses parties qui la composent. Alors la plantule ou l'embryon végétal, qui constitue la partie essentielle de cette semence, ne peut être considéré *ni comme jouissant de la vie,* car elle n'existe point sans mouvement organique, *ni comme en étant totalement dépourvue;* car ce qui la constitue peut être suspendu, et il l'est effectivement avant la germination si toutefois il existe. La *vie* alors n'attend qu'un stimulus particulier, et qu'un premier mouvement communiqué aux tendres organes de la plantule, pour jouir d'une existence active, et commencer à opérer les développemens qui résultent de son action."*

John Hunter was the first, I believe, who proved the vitality of Eggs. I had long supposed, says this illustrious Physiologist, that the principle of life was not wholly confined to animals, or animal substance endowed with visible organization and spóntaneous motion; but believed that the same principle might exist in animal substances, devoid of apparent organization and motion.

I was led to this opinion about twenty years ago, when busied in making observations on the growth of the chick in the process of incubation. I then observed, that whenever an egg was hatched, the yolk (which is not diminished in the time of incubation) was always perfectly sweet to the very last; and that the part of the albumen, which has not been expended on the growth of the animal, some days before hatching, was also perfectly sweet, although both were kept in a heat of 103° in the hen's egg for three weeks, and in the duck's for four; and I observed, that if an egg was not hatched, that egg became putrid in nearly the same time with any other dead animal substance. To determine how far eggs were possessed of a living principle I made the following experiments.

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* Until the period of *germination,* all the parts of a seed which are separate from the mother plant, are in a sort of complete repose; the contained fluids are in moderate quantity, without action, or movement; and we may suppose, that the equilibrium betwixt action and reaction of the different component parts is equal. Then the plantule, or essence of the seed, *cannot be said to possess life,* for this depends upon organic movement; nor can it be said *to be altogether deprived of life,* for this principle may be suspended, and is altogether so, before germination, *if indeed in that state it can be allowed to exist. Life* then would depend upon a proper *stimulus,* and this producing the first movements to the tender organs of the *plantule,* endows it afterwards with active existence, and the future developement which ensues.

FIRST EXPERIMENT.

AFTER having placed an egg in a cold about 17°, till it froze, I allowed it to thaw; by which process it was to be supposed that the preserving powers of the egg must be destroyed. I then put *this egg* into a frigorific mixture,* and with it *one newly laid,* and found the difference in freezing was seven minutes and a half, the fresh one resisting so much longer time the powers of cold.

SECOND EXPERIMENT.

A NEW laid egg being put into a cold atmosphere, fluctuating between 17° and 15°, took above half an hour to freeze; but when thawed and put into an atmosphere at 25°, it froze in half the time. This experiment was repeated frequently with nearly the same result.

To ascertain the comparative degree of heat between a living and a dead egg, and also to determine whether a living egg be subject to the same laws with the more imperfect animals, I made the following experiment.

THIRD EXPERIMENT.

A FRESH egg, and one which had been frozen and thawed, were put into the cold mixture at 15°: the thawed one soon came to 32°, and began to swell and congeal; the fresh one sunk to 29° and a half, and in twenty-five minutes later than the dead one, it rose to 32°, and began to swell and freeze.

In this experiment, the effect on the fresh egg was similar to that produced on the frog, eel, snail, &c. where life allowing the heat to be diminished two or three degrees below the freezing point, afterwards resisted all

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* The cold was first produced by means of ice and snow with sal ammoniac or sea-salt, to about the 10° of Fahrenheit's thermometer: ice was then mixed with spirit of nitre; but what degree of cold was then produced I did not, says John Hunter, examine. This cold mixture was made in a tub surrounded with woollen cloths, and covered with the same, to prevent the effects of the heat of the atmosphere upon the mixture itself, and to preserve as much as possible a cold atmosphere within the vessel.

BOOK SECOND.

A

BOTANICAL AND PHILOSOPHICAL

ENQUIRY

RESPECTING

ROOTS.

VOL. II.

THE
GENERA
of
Exotic and Indigenous
PLANTS
That are to be met with in
Great Britain;
Arranged
according to the
Reformed System,

BY

ROBERT JOHN THORNTON, M.D.

Late of Trinity College, Cambridge,

Physician to the Mary-le-bone Dispensary,

Fellow of the LONDON Medical Society,

Lecturer on Medical BOTANY *at Guy's Hospital,*

Author of The Philosophy of Medicine, and

The Politician's Creed.

Tomkins scr. _ Vincent scu.

GENERA

of

PLANTS

British

according to the

ROBERT JOHN THORNTON, M.D.

Physician to the Mary-le-bone Dispensary

[illegible] of the Philosophical [illegible]

DEDICATION,

BY PERMISSION,

OF

PART THE SECOND,

TO

CHARLOTTE,

QUEEN OF GREAT BRITAIN, &c. &c.

MADAM!

YOUR Majesty having graciously condescended to allow Your Majesty's sacred Name to be prefixed to PART I. containing the Philosophic Principles of Botany, with a full Explanation of the Sexual System of Vegetables, and my Reasons for reforming the same, demands my most grateful acknowledgments, and I pass on according to the plan laid out, from what may be styled the *theoretical* to the *practical* part of Botany; and in laying PART II. at the feet of Your Majesty, I should feel the utmost perturbation, unless the divine Attribute of Power, was both to ENCOURAGE LAUDABLE VIEWS, and to PARDON ERRORS, and I had known, that Your Majesty's great *Candour* was alone equalled by Your Majesty's *Knowledge* of the Subject, as almost all the plants in this Part have been not only reared by the tender Care of Your Majesty, an Attention worthy of a Monarch! but the *Heavenly Architecture* of Flowers has been also curiously traced, and finely portrayed by Your Majesty, and august Family; and that Your Majesty may long enjoy so pleasing and elegant a Recreation, is the sincere and ardent Prayer of,

MADAM!

Your Majesty's most obliged,

And devoted Subject,

ROBERT JOHN THORNTON.

PART II.

INTRODUCTION.

OF THE GENERA OF PLANTS.

> BOTANY resembles a plant of the Palm kind, which does not bloom for a century. It first put forth shoots in the reign of Alexander, was afterwards transported to Rome, where it grew no farther, and begun to fade. Being then carried over to Arabia, it revived, but its growth after this was stopped for a time, by the deadening effects of frost and snow, which melting from its roots (the dark age gone), it shewed a disposition to put forth blossoms (the germs of which appeared in GESNER, CÆSALPINUS, and COLUMNA), but the flower was feeble, and promised no harvest, when all at once, from a long respite, it resumed fresh vigour (from TOURNEFORT), and its fruit is now set, so as to constitute the present Golden Age of Botany.
>
> LINNÆUS.

THE faculties of all other creatures but Man are extremely limited.

NATURE is accused, as having sent him into this world "naked" and "defenceless."

But with what reason could Pliny thus degrade the condition of man? for, after having exercised the powers of his understanding, he is the most formidable of all beings.

The *warrior* armed with shield and spear is superior to every beast of the field.

In modern times the soldier can launch with a thundering noise, resembling the artillery of heaven, the weapons of death upwards of a mile, and overturn whole cities, as with an earthquake, or fire them, as with the lightnings of heaven!

How, again, can man be said to be *naked,* when he builds himself cities for shelter in the orders of architecture, and clothes himself with the furs of all the brutes of the forest!

Goldsmith, indeed, somewhere observes, what a poor contemptible being is the *naked savage,* standing on the beach of the ocean, trembling at its tumults! How little capable is he of converting its terrors into benefits; or of saying, "behold an element made for my use, not formed to separate, but unite the most distant nations." He, on the contrary, considers it as an angry deity, and pays to it the homage of timid adoration.

But it is very different, when he has exercised his mental powers; when he has learnt to find his own superiority; and to make it subservient to his commands. It is then that his real dignity begins to appear, and that the Deity is justly praised for having been " mindful of man;" for having given him " the earth for his habitation, and the sea for an inheritance."

This little intrepid being, by exerting his reason, carries the productions of the earth, partly natural, and partly forced, to every clime, in houses moving on the most turbulent of the elements; the sails are the wings of this new sea-monster, the rudder its tail, the compass its instinct, and the winds are its force.

Calling other instruments to assist him in the exercise of his sovereignty, he mounts the wild horse, puts iron points into his sides, and a bridle into his mouth, and realizes the story of the Centaurs; or he even erects castles on the backs of elephants, to carry on his design of being revenged on his enemies.

In more tranquil seasons, he contrives instruments to discover mountains in the moon, belts around the planets, their attendant satellites, and sees new wonders in the heavens.

Or, by means of a microscope, which so surprisingly enlarges the limits of vision, he beholds a whole race of unobserved beings in an atom.

Thus does man advance his powers by the contrivances of his reason. But, alas! as Hippocrates hath well observed,

> Ars Longa, vita brevis.
> Art is long, life is short.

and as we might expect, the progress of invention must naturally be slow in what relates more towards the embellishments of life, than its necessities.

Hence the tardy steps of botany as a science, or those *artificial aids* without which it cannot possibly be acquired.

The objects which this embraces are so numerous, that unless we divide, and subdivide, which is a species of mechanical art, all otherwise would be a labyrinth of confusion.

This will be best understood by comparing our science with the noble study of astronomy.

The ignorant man gazes with silent astonishment at the innumerable stars twinkling in the vault of heaven, and to name each, would seem to him an endless and impossible task.

The philosopher, like the man who would mount a wall, and contrives a ladder, so he first imagines a line dividing the heavens, the ecliptic, and the space on each side of this he calls the *northern* and *southern hemispheres.*

This abridges one half of the objects he would wish to teach.

He next makes certain *figures*[*] over these two hemispheres, each comprehending a given number of stars, for example, the Plough contains seven stars, Orion 78, the Ram 40, and so the whole heavens are divided into constellations, or parcels, as both rulers and geographers have divided the earth into kingdoms, provinces, and districts.

And thus with the botanist, he having found out the *Class* and *Order* of any plant, his next step is the *Genus,* which comprehends a definite number of individuals.

In the sciences above mentioned, these parcels are mostly arbitrary, and generally fanciful and accidental; but, on the contrary, the Genera of plants are, according to Linnæus, perfectly natural.

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[*] The first and most important discoveries in *astronomy* are due to the Egyptians. In Egypt there were four colleges, where science was studied and taught: Thebes, which Pythagoras visited; Memphis, where Thales and Democritus consulted the Egyptian priests; Heliopolis, where Plato studied; and Sais, where Solon was instructed in the principles of legislation and government. The climate of Egypt was peculiarly favourable to the study of this interesting science. Night discloses a thousand charms, which it seldom falls to the lot for the Northern inhabitant to behold. Through a transparent veil which only half conceals the objects of nature, the spectator contemplates the azure of a serene sky, and an infinite number of stars which bespangle the firmament. These appear larger than in the more temperate climates, and produce a more brilliant light. Thick darkness never conceals the heavens. The blasts of tempests never disturb its tranquillity. The winds fall with the sun, and nature remains in a perfect calm. The Egyptians mostly sleep out of doors; and enjoying the sight of such a firmament, they were naturally led to follow the motion of the stars throughout the immensity of space. Their obelisks were therefore erected as gnomons for astronomy, and the sides of the great pyramids corresponded exactly to the four cardinal points. The figures of their constellations were many of them deserving of much commendation. The *Plough* has all the appearance of the outline of that useful instrument; and the common observer can readily fancy the head, arms, breast, legs and even the sword, of the giant *Orion.* The *Ram* and the *Bull* are expressive of the season of love; the *Twins* denote increase; and the *Crab* alludes, as the animal walks backwards, to the sun leaving the northern tropic at the summer solstice, and drawing back towards the south. *Leo,* the *Lion,* denotes the fury and heat of the dog-days. The *Virgin* has an ear of corn in her hand, which is the emblem of harvest. The *Balance* presides at the autumnal equinox, and aptly represents the medium, or balance, between heat and cold, winter and summer. The *Scorpion* alludes to the pestilence prevailing during autumn. The *Archer* denotes the time arrived for hunting. The *Goat* implies the return of the sun from his southern limit, and his climbing up towards the north, as the Goat ascends the mountains. *Aquarius,* a figure pouring out water, points at the rainy season of winter; and the *Fishes,* the last sign of the Zodiac, the food necessary to be employed in addition to the winter's stock.—Vide Mr. Walker's charming System of familiar Philosophy, a work that ought to be in every one's hand.

Thus any one presented with a moss, or a damask rose, would at once declare it to be of the Genus, the Rose (Rosa), as both flowers would agree in certain characters; or with a geranium, whether it has leaves, or not, the resemblance of the fructification would at once make him combine the several species under the term, Geranium. So with the several ranunculuses, the lychnesses, the lamiums, the passifloras, &c. these would severally unite together so as to make a compound word including the several species.

A Genus, therefore, is an assemblage of several distinct species; that is, of several plants, which resemble each other in their fructification, either altogether, or nearly so.

By this assemblage those plants of the same family are brought together under one view, and the memory is not unnecessarily burdened with as many different names as there are plants, which must have pressed down the science itself by the weight of its own nomenclature.

Thus in common life are the several persons composing different families, called by the family name, as the Bedford family possesses John, Duke of Bedford, Francis, Duke of Bedford, and here Bedford is the generic name; so to take the names of Cæsar, George, Louis, these all have a name in common, and Cæsar Augustus, George III, Louis XVI, are but individuals included in a certain distinct group of personages having one common, or family name.

With regard to animals, or birds, such generic names were also in early acceptation, as that is a hawk, that an eagle, that an owl, that of the tiger kind, that a species of humming bird, that a dog, and many were content with this kind of knowledge, without troubling themselves any farther, leaving it to more knowing persons to say, of what species.

But plants for a long period had not this sort of honour bestowed on them, and it is no wonder, as the attainment of botany originally was no other than a certain limited knowledge of a few plants, chiefly medicinal, or economical.

This was the state of Botany in the times of Theophrastus, Dioscorides, Pliny, and Galen. Afterwards all Europe was plunged in total darkness,* and Botany, like other arts, was wholly neglected. On the revival of learning in the fifteenth century, men were solely devoted to the study of the

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* " A sample of this age may be given from an anecdote mentioned in Anna Comnena's history of her father Alexius, who was Grecian emperor in the eleventh century, when the first crusade arrived at Constantinople. So promiscuous a rout of rude adventurers could not fail of giving umbrage to the Byzantine court, which was stately and ceremonious, and conscious withal of its internal debility.

After some altercation, the court permitted them to pass into Asia through the imperial territories, upon their leaders taking an oath of fealty to the emperor.

What happened at the performance of this ceremonial, is thus related by the fair historian above mentioned.

" All the commanders being assembled, and Godfrey of Bulloign himself among the rest, as soon as the oath was finished, one of the counts had the audaciousness to seat himself beside the emperor upon his throne. Earl Baldwin, one of their own people, approaching, took the count by the hand, made him rise from the throne, and rebuked him for his insolence."

" The count arose, but made no reply, except it was in his own native jargon, to mutter abuse upon the emperor."

" When all things were dispatched, the emperor sent for this man, and demanded, by means of an interpreter, who he was, whence he came, and of what lineage?—His answer was as follows—I am a genuine Frank, and in the number of their nobility. One thing I know, which is, that in a certain part of the country I came from, and in a place where three ways meet, there stands an ancient church, where every one who has a desire to engage in single combat, having put himself into fighting order, comes, and there implores the assistance of the Deity, and then waits in expectation of some one that will dare attack him. On this spot I myself waited a long time, expecting and seeking some one that would arrive and fight me. But the man, that would dare this, was no where to be found."

" The emperor, having heard this strange narrative, replied pleasantly—If at the time when you sought war, you could not find it, a season is now coming in which you will find wars enough. I therefore give you this advice; not to place yourself either in the rear of the army, or in the front, but to keep among those who support the centre; for I have long had knowledge of the Mahometan method in their wars."

This was one of those counts, or barons, the petty tyrants of western Europe; men, who, when they were not engaged in general wars (such as the ravaging of a neighbouring kingdom, the massacring of infidels, heretics, &c.) had no other method of filling up their leisure, than, through help of their vassals, by waging war upon each other.

And here the humanity of the church cannot enough be admired, when by her authority (which was then mighty) she endeavoured to shorten that scene of bloodshed, which she could not totally prohibit. The truce of God (a name given it purposely to render the measure more solemn) enjoined these ferocious monsters, under the terrors of excommunication, not to fight from Wednesday evening to Monday morning, out of reverence to the mysteries accomplished on the other four days; the ascension on Thursday; the crucifixion on Friday; the descent to hell on Saturday; and the resurrection on Sunday.

I hope a farther observation will be pardoned, when I add that the same interference prevailed during the fourteenth century, and that the terrors of church power were then held forth with an intent equally laudable. A dreadful plague at that period desolated all Europe. The Germans, with no better reason than their own senseless superstition, imputed this calamity to the Jews, who then lived among them in great opulence and splendour. Many thousands of these unhappy people were inhumanly massacred, till the Pope benevolently interposed, and prohibited, by the several bulls, so mad and sanguinary a proceeding."

As an epitome of all the rest you have the following history.

" When Alexandria was taken by the Mahometans, Amrus, their commander, found there Philoponus. On a certain day Philoponus said to him: ' You have visited all the repositories or public warehouses in Alexandria, and you have sealed up things of every sort that are found there. As to those things that may be *useful* to you, I presume to say nothing; but as to things of no service to you, some of them perhaps may be more suitable to me.' Amrus said to him: ' And what is it you want?' ' The philosophical books (replied he) preserved in the libraries.' ' This (said Amrus) is a request upon which I cannot decide. You desire a thing, where I can issue no orders till I have leave classics, to recover that knowledge which was so long lost in obscurity. Hence botany was brought back to its pristine state.* But in 1559 Conrad

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from Omar, the commander of the faithful.'—Letters were accordingly written to Omar, informing him of what Philoponus had said; and an answer was returned by Omar, to the following purport: 'As to the books of which you have made mention, if there be contained in them what accords with the book of God (meaning the Alcoran) there is no want of them, in the book of God is contained all that is sufficient. But if there be any thing in them repugnant to that book, we in no respect want them. Order them therefore to be *all* destroyed.'

The night of barbarism continued for four centuries, " during which period, not a single discovery," says Gibbon, " was made to exalt the dignity and happiness of mankind. Not a single idea was added to the speculative systems of philosophy: they held in their lifeless hands the riches of antiquity, without inheriting the spirit, which had created, and improved, that sacred patrimony. Their languid souls were alike incapable of thought, or generous action. Their understandings were bewildered in the belief of visions, and miraculous interpositions, and they seemed to have lost all common sense, and the darkness was so thick, that few even of the monks could so much as write their names, and a layman who could accomplish so far was allowed the privilege of clergy, as a recompense for this great and mighty acquisition." How mankind emerged from this dreadful condition the reader will find recorded in the next note.

* Historians have assigned different reasons for the human race emerging from their dark estate of barbarism. The accidental discovery of the *Institutes of Justinian* is eagerly caught at by Blackstone, as first leading to the restoration of the man's dignity, by shewing him his rights and the regulation of his conduct, and the *lawyers* are reported as the first refiners of themselves, and of mankind. Others have painted the *crusaders* as the civilizers of society, and the romantic honour of the warrior atoned for the murder of the infidel.—There is an ancient passage often quoted,

Ingenuas didicisse fideliter artes
Emollit mores, nec sinit esse feros.

And to *the study of the classics* has a third attributed this great change. " In the resurrection of science," says Gibbon, " Italy was the first that cast away her shroud; and the poet Petrarch by his writings and example may be justly applauded as the first harbinger of day." When presented with a transcript of Homer by a Byzantine ambassador, he thus feelingly deplores his ignorance of the Greek language, and resolves to undertake the study of it. " Alas! Homer is dumb, and I am deaf; for want of an interpreter I cannot enjoy the treasure I possess. I have seated him by the side of Plato, the prince of poets next to the prince of philosophers; and I glory in the sight of my illustrious guests. I am delighted with the company of Homer; and as often as I embrace the silent volume, I utter a sigh, that I cannot understand his sweet harmony; but I do not despair, old as I am, after the example of Cato, of having the unspeakable satisfaction of hearing these venerable Greeks uttering their thoughts in their own tongue." The diversified writings of Petrarch struck with admiration a barbarous age; and the senate of Rome, along with the people, invited him publicly to accept a crown of laurel. The ceremony of this coronation was performed in the capitol: twelve patrician youths were arrayed in scarlet, ten representatives of the most illustrious families in green robes, with garlands of flowers, accompanied the procession; in the midst of the princes and nobles, the aged senator Anguillara mounted the throne, and at the voice of the herald Petrarch stood up. He made his oration, and then kneeling, received from the hand of the senator a crown of laurel, with the more precious declaration, " that it was the reward of merit," when the whole audience shouted, " long live the *Poet-laureat*."—To the revival of poetry succeeded that of *criticism*. Printing was discovered; but in this dark age the inventor was forgotten. This art multiplied the *ancient authors*, whose fame passed down the current of time undiminished, and the sense, though not the spirit, of the *Greek classics*, was transfused into the Latin tongue; and the original text was corrected and explained by the early *scholiasts*. Theodore Gaza undertook the literal version of the more solid works of Aristotle and Theophrastus, and their natural histories of animals, and plants, opened a rich field of genuine science, and when added to the works of Pliny, may be justly esteemed the restoration of this branch of knowledge.

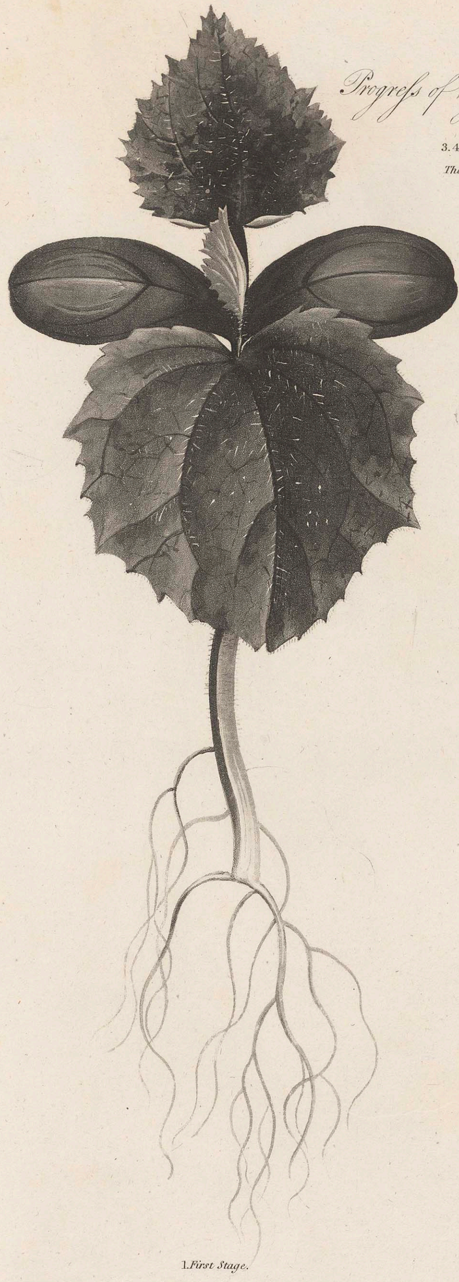
CLASS I.

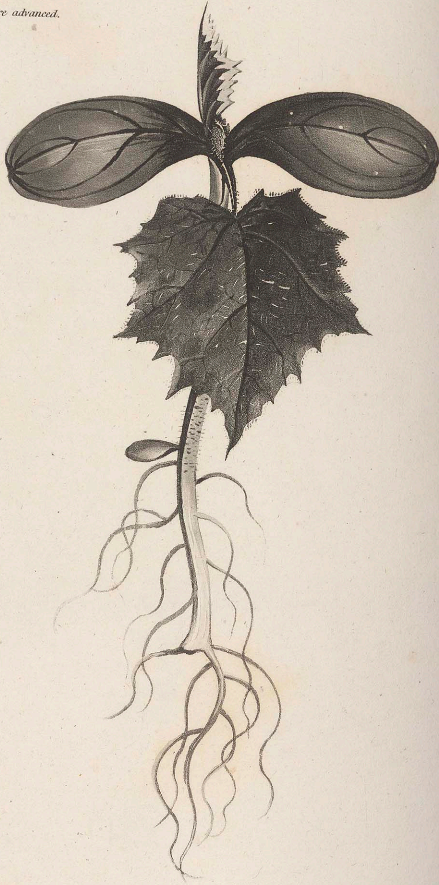
ONE

STAMEN.

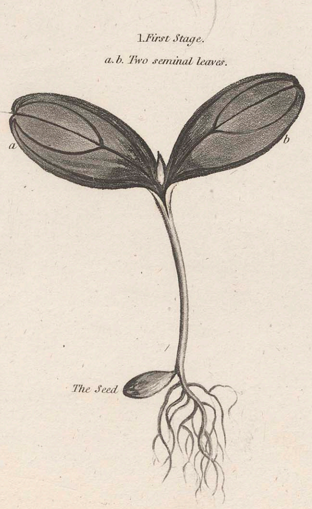
Progreſs of Vegetation in the Cucumber

3.4. The Third and Fourth Stages.
These hairy leaves more advanced.

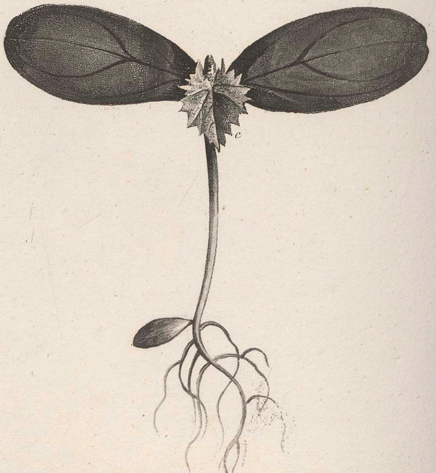




1. First Stage.
a. b. Two seminal leaves.



2. Second Stage.
c. The common leaves at first hirsute.

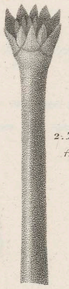


Henderson del.

London, Published by Dr. Thornton, March 1 1806.

Sutherland sculp.

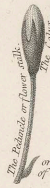
Anatomy of the Meadia.



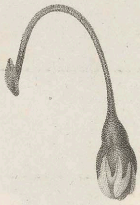
1. Top of the Scape fringed with small leaves termed by botanists the Involucrum, whence issue the several Peduncles forming an Umbel.

2. The Scape, a stem without leaves, arising immediately from the ground and elevating the fructification.

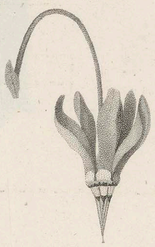
3. First Stage, Peduncle upright Calyx closed.


The Peduncle or flower stalk.
The Calyx.
one of the Leaves of the Involucrum.

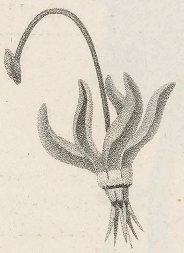
4. Second Stage, Peduncle pendent Corolla peeping.



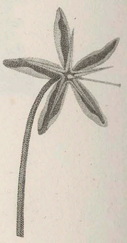
5. Third Stage, Corolla reflexed Stamens converging.



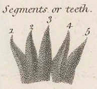
6. Fourth Stage, Stamens diverging.



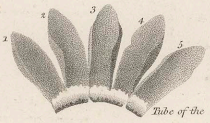
7. Fifth Stage, Peduncle partly upright, Corolla withered Stamens at right angles with the Pistillum.



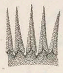
8. Calyx spread open to shew its five Segments or teeth.



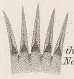
9. The five Segments of the Corolla displayed in the same way.



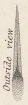
10. The five Stamina displayed, Inside view.



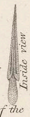
11. The five Stamina. Outside view to shew the five Nectaries.


the 5 Nectaries.

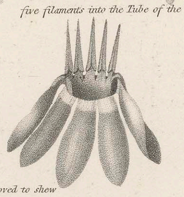
12. A Stamen.



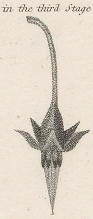
13. A Stamen.



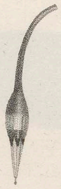
14. Insertion of the five filaments into the Tube of the Corolla.



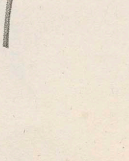
15. The Corolla removed to shew the reflexed Segments of the Calyx, as in the third Stage.



16. The Corolla and Calyx removed to shew the converging of the five Stamina, as in the third Stage.

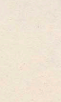


17. Sixth Stage, The Corolla and Stamens dropt, leaving the Pistillum (whose Germen or Seed-veſsel is considerably encreased) surrounded by the Calyx, which gradually loses its reflexed State.

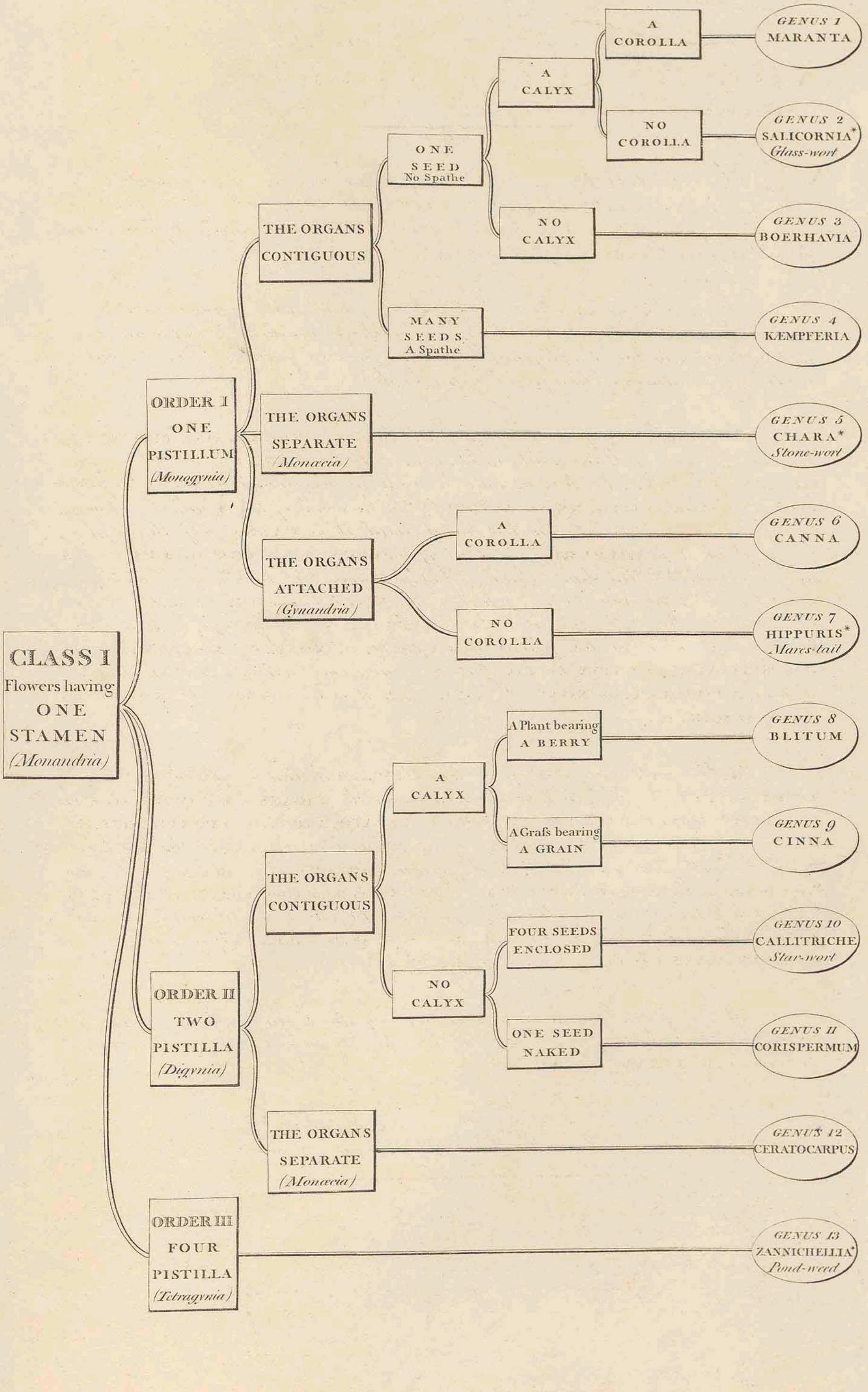


19. The Seed-veſsel cut open to shew the seeds surrounded by a Pericarp.

18. Last Stage, The Calyx enclosing the Germen or Seed-veſsel.



ANALYSIS OF CLASS I.


CLASS I
Flowers having
ONE
STAMEN
(Monandria)
ORDER I
ONE
PISTILLUM
(Monogynia)
THE ORGANS
CONTIGUOUS
ONE
SEED
No Spathe
A
CALYX
A
COROLLA
GENUS 1
MARANTA
NO
COROLLA
GENUS 2
SALICORNIA*
Glass-wort
NO
CALYX
GENUS 3
BOERHAVIA
MANY
SEEDS
A Spathe
GENUS 4
KÆMPFERIA
THE ORGANS
SEPARATE
(Monœcia)
GENUS 5
CHARA*
Stone-wort
THE ORGANS
ATTACHED
(Gynandria)
A
COROLLA
GENUS 6
CANNA
NO
COROLLA
GENUS 7
HIPPURIS*
Mares-tail
ORDER II
TWO
PISTILLA
(Digynia)
THE ORGANS
CONTIGUOUS
A
CALYX
A Plant bearing
A BERRY
GENUS 8
BLITUM
A Graſs bearing
A GRAIN
GENUS 9
CINNA
NO
CALYX
FOUR SEEDS
ENCLOSED
GENUS 10
CALLITRICHE
Star-wort
ONE SEED
NAKED
GENUS 11
CORISPERMUM
THE ORGANS
SEPARATE
(Monœcia)
GENUS 12
CERATOCARPUS
ORDER III
FOUR
PISTILLA
(Tetragynia)
GENUS 13
ZANNICHELLIA*
Pond-weed

The * denotes the Plant to be a native of Great Britain.

London Published May 1. 1798, for Dr. Thornton.

Vincent Sculp.

Explanation
OF THE
SECOND TABLE

The **SEXUAL SYSTEM** is capable, as we saw in the first Table, of being reduced to the greatest simplicity. The Claſses were all derived from the Number of **STAMINA**, and the Orders from a Similar Consideration of the **PISTILLA**; and had there not been a kind of Natural Aſsemblage in the Gynandrious and Monœcious Flowers (vide Tab. III), this Simplification would have had most Voices: But as many persons would not wish to see compleatly torn asunder Plants having so much of Natural Affinity, **ANOTHER SCHEME** is here proposed, which the avowed Enemies to Reform can scarcely find room to object to, and is such, to use the language of the Critic,* "as Linnæus would have in all probability himself accepted." It avoids the neceſsity of employing the same terms first as Claſses, and then as Orders, which so much perplexes the Student, when commencing this elegant Science. The Claſses are now each derived from the single consideration of the Number of **STAMINA**, and the Orders from the Diversities in the **PISTILLA**. In the present more comprehensive Tables the reader will find not alone the Genera that were seen by Linnæus, but all such as have been introduced into our Gardens, or are to be met with wild in our Fields. It therefore contains with Tab. III, all the indigenous and exotic plants at present (as far as my Enquiries could reach) in **GREAT BRITAIN**, coming under the Claſs **MONANDRIA**, One Stamen. As in the other Table, so here, we start with a Comparison, and adjusting the point in question, we proceed on examining Differences, which lead to a Separation at each step, until we arrive ultimately to the Name of each Unknown Plant. It is thus with the Mathematics we go from known Propositions to unknown, till at length we arrive at the ultimatum, quod erat probandum. So with Algebra: And in Chemistry we also proceed by Analysis, which is the separation of a Compound into its several Parts: and thus exercising our Reason and Judgment in a manner not poſsible to the brute Creation, and on a Subject alone appropriated to the ken of mortals, we follow our peculiar privilege, and elevate our Natures, and as we advance our reasoning powers, we at the same time acquire an agreeable stock of knowledge, so that by this Analytical Mode of studying Botany we rise far superior to that Contempt which is commonly cast upon this lovely Science, by those who are ignorant of our Procedure. In a Word, when Botany is thus studied, there is not a more excellent book of Logic, or Reasoning, in the world; or it must be allowed on every side to be a manly sort of **PUZZLE**, as amusing, as it is instructive.

---

* Vide the British Critic for the Month of June 1800.

Second Scheme.

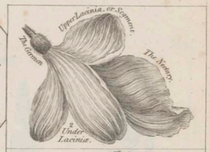
ANALYSIS of CLASS I.

MONANDRIA (*One Stamen.*)

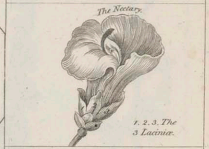
I. FLOWERS OF COMMON CONSTRUCTION.‡

- Order I. *MONOGYNIA* (*Having 1 Pistillum.*)
  - COROLLA *1 petalled* (*consisting of 1 piece only.*)
    - *The* Limb *cut* (*the Limb is the upper expanded part of a monopetalous Corolla.*)
      - *3 partite* (*divided beyond the middle of the petal into 3 Parts, called* Segments, *or* Laciniæ)
        - Flowers *pendent* (*looking towards the Earth.*) …… Gen. 1.
        - ——— *erect* (*towards the Heaven.*) …… Gen. 2.
        - ——— *lateral* (*towards the Horison.*) …… Gen. 3.
      - *4 partite* (*4 Segments.*) …… Gen. 4.
      - *5 partite* (*5 Segments.*) …… Gen. 5.
      - *6 partite* (*6 Segments.*)
        - *The lower* Segment *2 partite.* …… Gen. 6.
        - *All the* Segments *entire.* …… Gen. 7.
    - Limb *entire* (*without division.*) …… Gen. 8.
  - ——— *5 petalled* (*composed of 5 distinct pieces*) …… Gen. 9.
  - ——— *apetalled* (*without Corolla.*) …… Gen. 10.
- Order II. *DIGYNIA.* (*2 Pistilla.*)
  - FRUIT *a berry* …… Gen. 11.
  - SEED *naked* (*not enclosed in pulp*) …… Gen. 12.

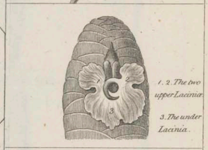
Gen. 1.
RENEÁLMIA.
st. per.
Fl. May. _ July.


The Germen
Upper Lacinia, or Segment.
The Nectary.
2
Under
Laciniæ.

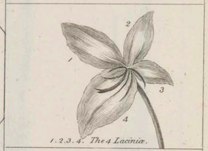
Gen. 2.
CÓSTUS.
st. per.
Fl. in August.


The Nectary.
1
2
3
1. 2. 3. The
3 Laciniæ.

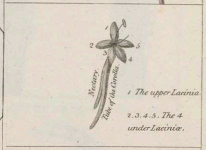
Gen. 3.
AMÓMUM.
st. per.
Fl. Sept. _ Nov.


1
2
3
1. 2. The two
upper Laciniæ.
3. The under
Lacinia.

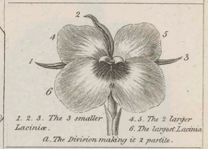
Gen. 4.
CURCÚMA.
st. per.
Fl. in August.


1
2
3
4
1. 2. 3. 4. The 4 Laciniæ.

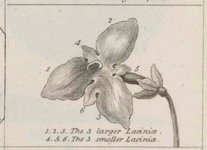
Gen. 5.
VALERIÁNA.
rubra
Ind.
Fl. in August.


1
2
3
4
5
Nectary.
Tube of the Corolla.
1 The upper Lacinia.
2. 3. 4. 5. The 4
under Laciniæ.

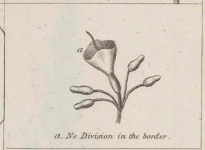
Gen. 6.
KÆMPHÉRIA.
st. per.
Fl. June _ Sept.


1
2
3
4
5
6
a
1. 2. 3. The 3 smaller
Laciniæ.
4. 5. The 2 larger
6. The largest Lacinia
a. The Division making it 2 partite.

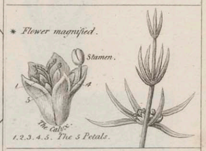
Gen. 7.
MARÁNTA.
st. per.
Fl. April _ Sept.


1
2
3
4
5
6
1. 2. 3. The 3 larger Laciniæ.
4. 5. 6. The 3 smaller Laciniæ.

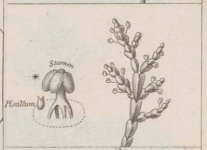
Gen. 8.
BOERHÁVIA.
gr. h. per.
Fl. Sept.


a
a. No Division in the border.

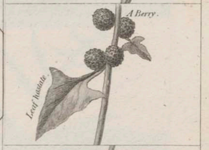
Gen. 9.
POLLÍCHIA.
gr. h. per.
Fl. Sept.


* Flower magnified.
Stamen.
1
2
3
4
5
The Calyx.
1. 2. 3. 4. 5. The 5 Petals.

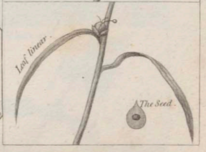
Gen. 10.
SALICÓRNIA
Ind.
st. and abr.
Fl. Aug. _ Sept.


Stamen
*
Pistillum

Gen. 11.
BLÍTUM.
abr. an
Fl. May _ Aug.


A Berry.
Leaf hastate.

Gen. 12.
CORISPÉRMUM
abr. an
Fl. July _ Sept.


Leaf linear.
The Seed.

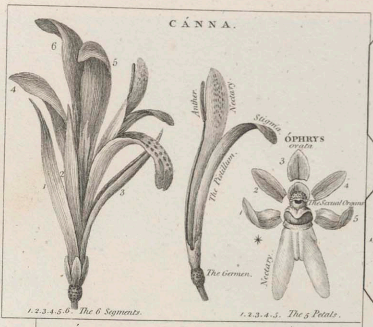
Dr Thornton inven.

Caldwall ſculp.

CONTINUATION of the ANALYSIS of CLASS I.

MONANDRIA (*One Stamen*)

- II. FLOWERS OF PECULIAR CONSTRUCTION.
  - Ord. III. *GYNANDRIA* (*The Sexual Organs confused, or intermixed.*)
    - A COROLLA
      - 1 Petal (*6 partite*) (CÁNNA)
      - 5 Petals (ÓPHRYS *spiralis & ovata.*)
    - No COROLLA
      - Spathe *hollow* (ÁRUM)
      - ——— *flat* (CÁLLA)
  - Ord. IV. *MONŒCIA* ‡ (*The Sexual Organs, the Stamina and Pistilla, apart; but on the ſame Plant.*)
    - TREES
      - Fruit *a cone* (*a ſtrobile*) (CASUARÍNA)
      - ——— *round* (*a cluſtre of berries*) (ARTOCÁRPUS)
    - Obscure AQUATIC PLANTS
      - *A linear* Spadix (*Fructification on one ſide the spadix only.*) (ZOSTÉRA)
      - *No* Spadix
        - Leaves *verticillate.*
          - Flowers *axillary* (Stigma 1. *ending acute.*) (HIPPÚRIS)
          - ——— *Never axillary* (Stigma 1. *with 5 teeth.*) (CHÁRA)
        - ——— *alternate, or opposite.* (*Not verticillate*)
          - Leaves *liniar* (Stigmata 4) (ZANNICHÉLLIA)
          - ——— *spatulate* (Stigmata 2) (CALLÍTRICHE)

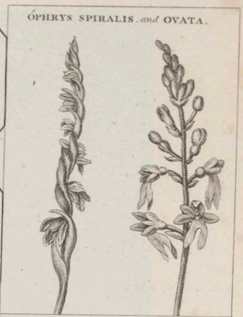

CÁNNA.

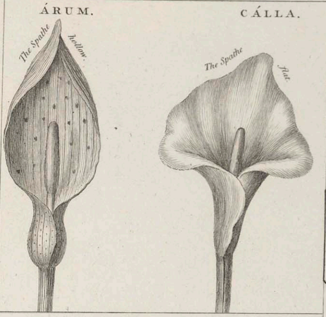
1.2.3.4.5.6. The 6 Segments.

1.2.3.4.5. The 5 Petals.
6
5
4
2
1
3
Anther.
Nectary.
The Pistillum.
Stigma.
The Germen.
ÓPHRYS ovata
3
2
4
The Sexual Organs
1
5
*
Nectary.

Gen. 13.
CÁNNA.
st. per.
Fl. most part of the year.

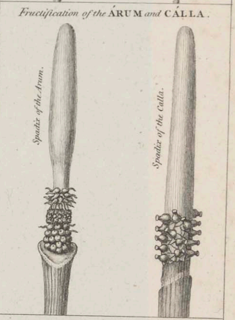
Gen. 14.
ÓPHRYS.
Spiralis and ovata.
Ind.
abr. an.
Fl. May_August.

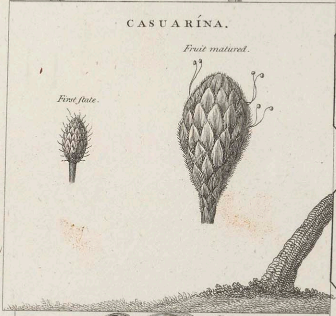

ÓPHRYS SPIRALIS, *and* OVATA.


ÁRUM.
CÁLLA.
The Spathe hollow.
The Spathe flat.

Gen. 15.
ÁRUM.
Ind.
abr. gr. b. & st. per.
Fl. March_July.

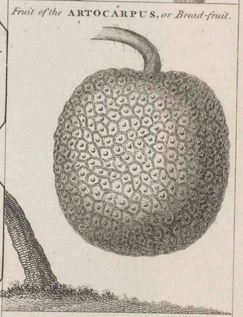
Gen. 16.
CÁLLA.
abr. & gr. b.
Fl. Jan._August.

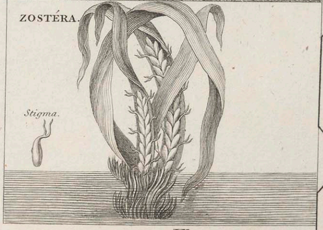

Fructification of the ÁRUM *and* CÁLLA.
Spadix of the Arum.
Spadix of the Calla.


CASUARÍNA.
First state.
Fruit matured.

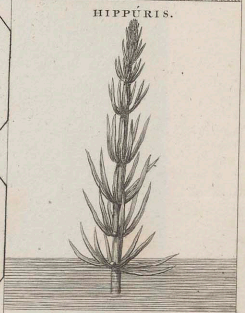
Gen. 17.
CASUARÍNA.
st. & gr. b. per.
Fl. Oct._Dec.

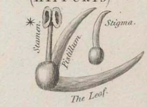
Gen. 18.
ARTOCÁRPUS.
st. per.
Fl.


Fruit of the ARTOCÁRPUS, *or Bread-fruit.*

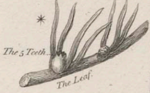

ZOSTÉRA.
Stigma.

Gen. 19.
ZOSTÉRA.
Ind.
abr. per.
Fl. August.

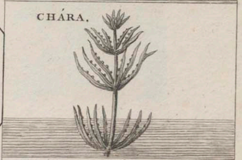

HIPPÚRIS.

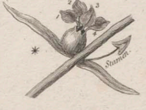

*
Stamen.
Pistillum.
Stigma.
The Leaf.

Gen. 20.
HIPPÚRIS.
Ind.
abr. an.
Fl. May.

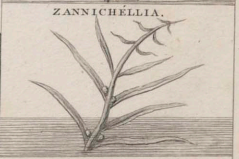

*
The 5 Teeth.
The Leaf.

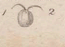
Gen. 21.
CHÁRA.
Ind.
abr. an.
Fl. July_Sept.


CHÁRA.

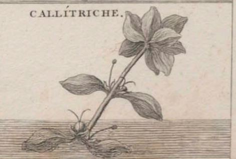

1
2
3
4
*
Stamen.

Gen. 22.
ZANNICHÉLLIA.
Ind.
abr. an.
Fl. July.


ZANNICHÉLLIA.



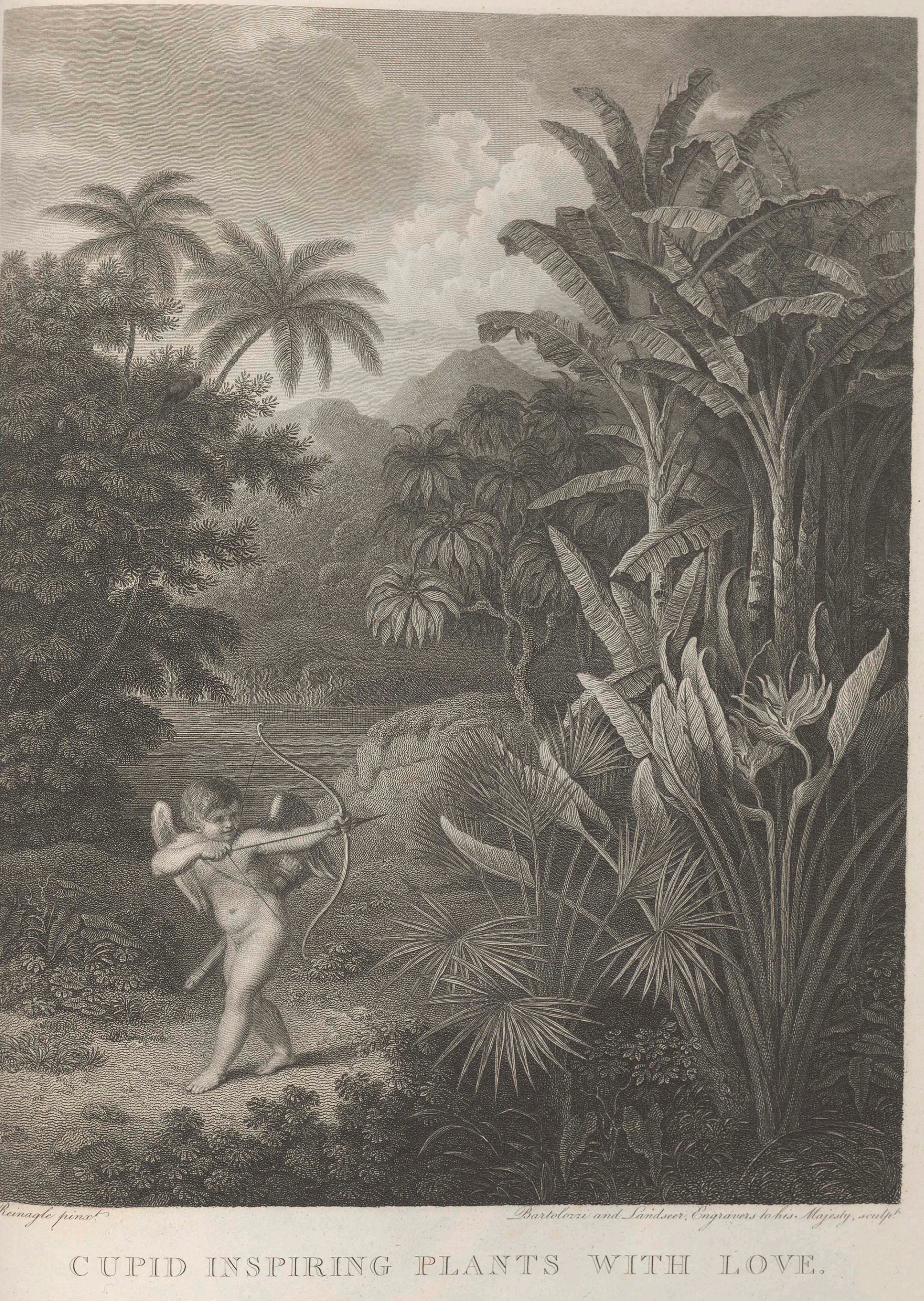
Gen. 23.
CALLÍTRICHE.
Ind.
abr. an.
Fl. April_Sept.


CALLÍTRICHE.

---

* *Denotes that the parts expreſsed have been magnified.*

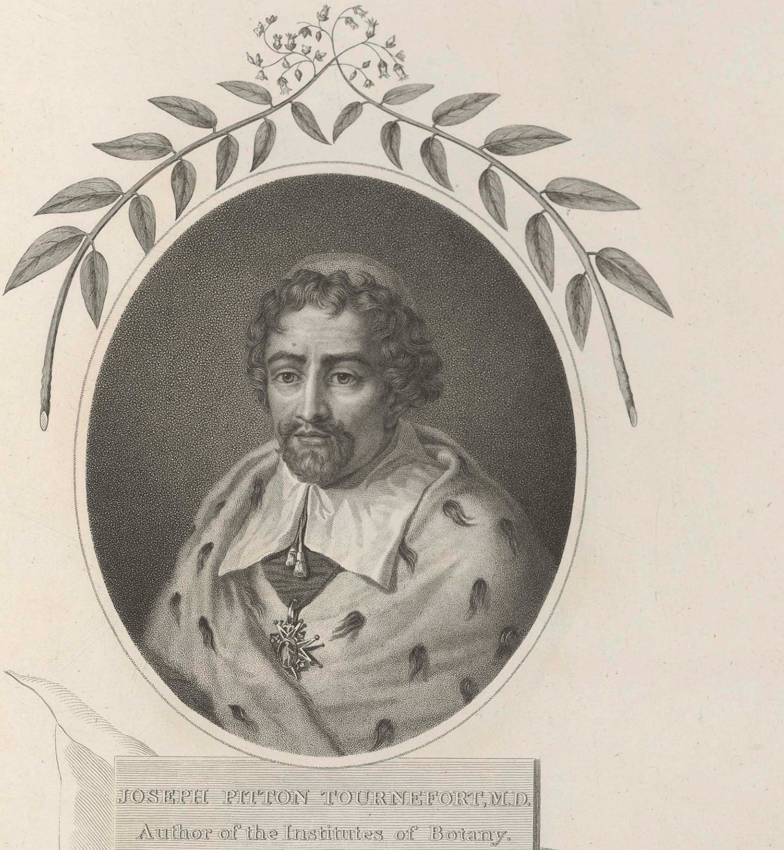
‡ *The character of the order* MONŒCIA *is, in the present examples, very uncertain, but in branching into two such Subdivisions* TREES *and obscure* AQUATIC PLANTS, *all difficulty is at once banished to the investigator, and the Stigmata furnish the line of comparison, if wanted.*



Reinagle pinx^{t}. *Bartolozzi and Landseer, Engravers to his Majesty, sculp^{t}.*

CUPID INSPIRING PLANTS WITH LOVE.

London, Published May 1. 1800, by Dr Thornton.

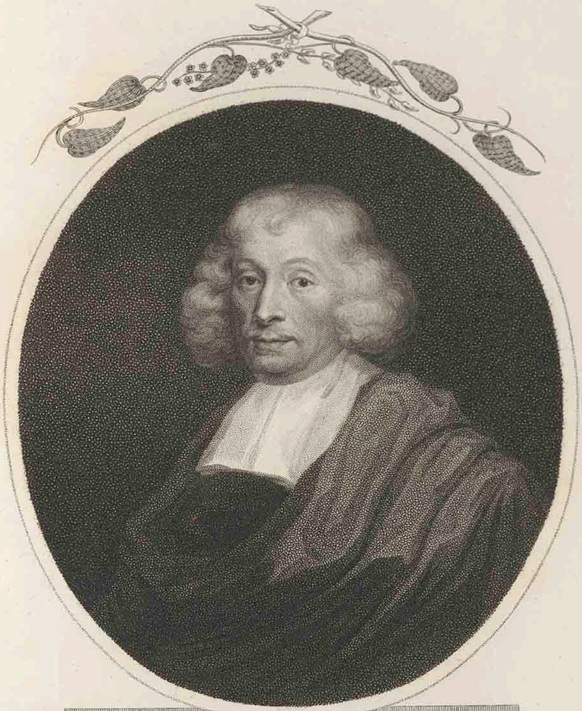

CLASSES.
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
XV
XVI
XVII

JOSEPH PITTON TOURNEFORT, M.D.
Author of the Institutes of Botany.

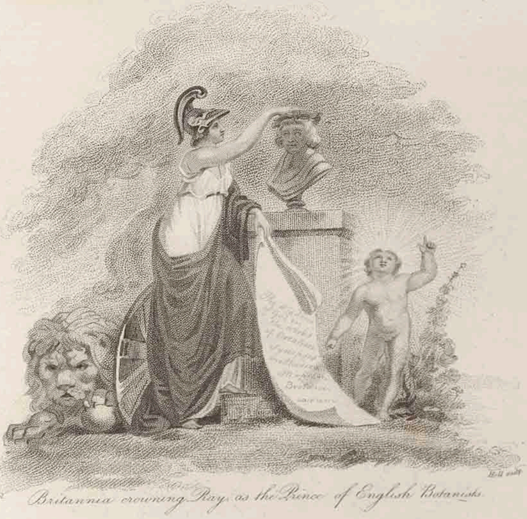
A Zephyr disclosing to an astonished world, the System of Tournefort.

Hopwood sculpt.

London, Published August 1. 1802, by Dr. Thornton from an original French picture in the possession of the family.



The Revd. JOHN RAY, A.M. F.R.S.
Author of Hiſtoria Plantarum.

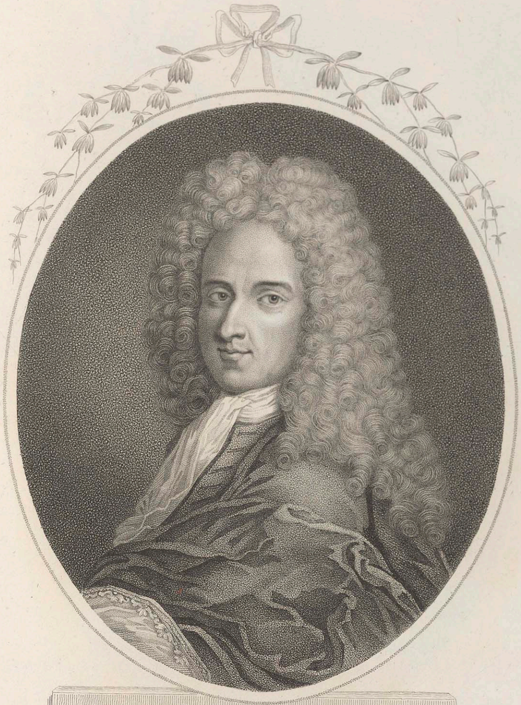


Uwins del. Holl sculp.

Britannia crowning Ray as the Prince of English Botanists

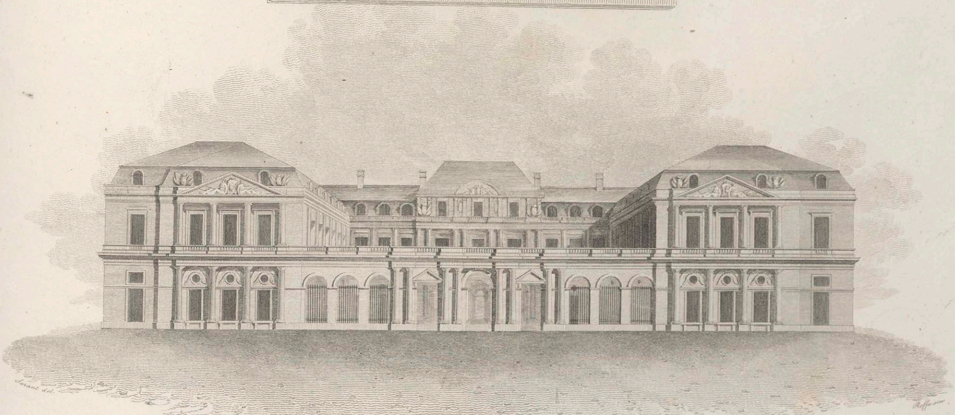
N.B. This Picture is in the British Museum.

Mrs Beale pinx.



SEBASTIAN VAILLANT,

AUTHOR OF BOTANICUM PARISIENSE.



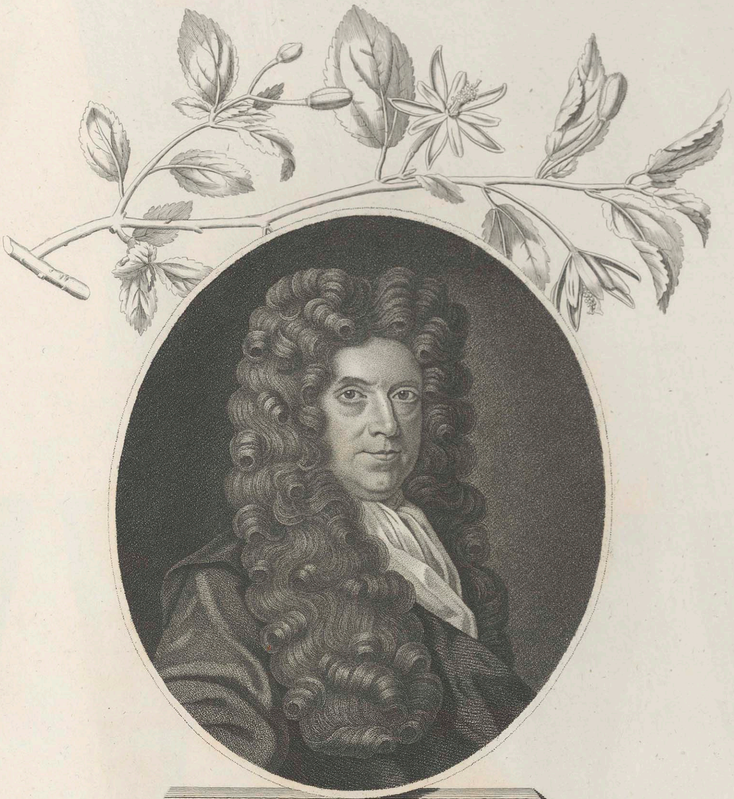
Sarant del.

Roffe sc.

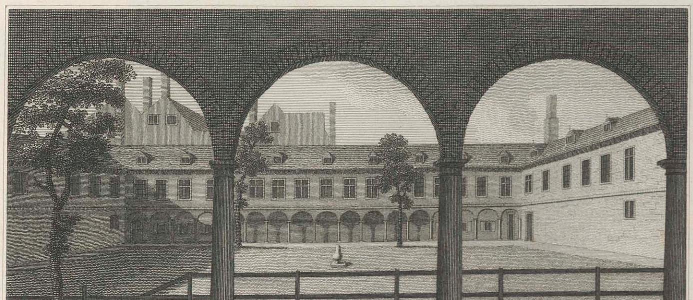
A View of the Palais Royale

Aubret pinx.t *Hopwood sculp.t*

London, Published by D.r Thornton, November 1803.



NEHEMIAH GREW, M.D.
SECRETARY TO THE ROYAL SOCIETY



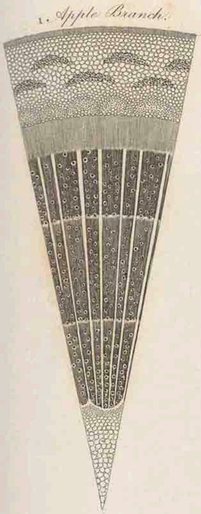
Gresham College, where the first Meetings of the Royal Society were held.

Newton sculp.

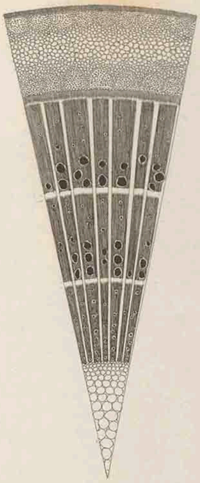
London, Published for Dr. Thornton November 1st, 1800.

Transverse Sections chiefly of Wood, as viewed through a Microscope, from Grew's Anatomy of Plants.

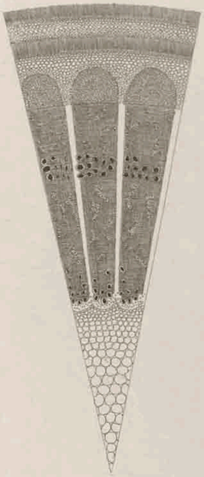
1. Apple Branch.



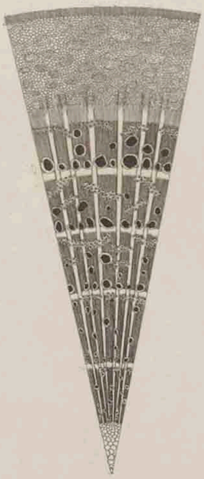
2. Ash.



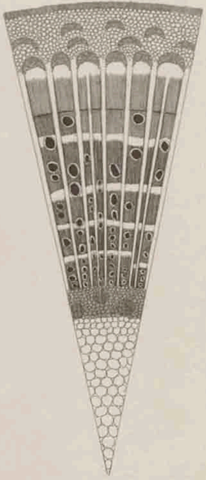
3. Barberry.



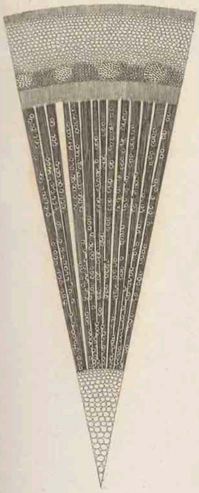
4. Elm.



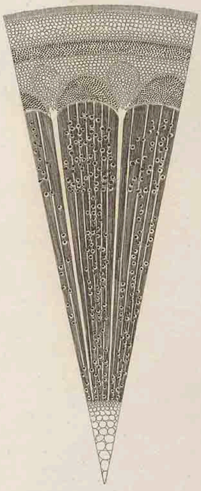
5. Fig.



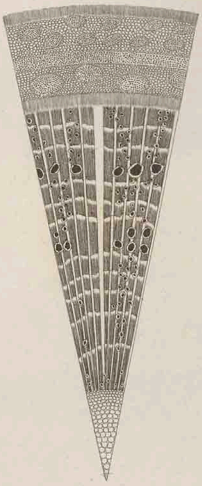
6. Holly.



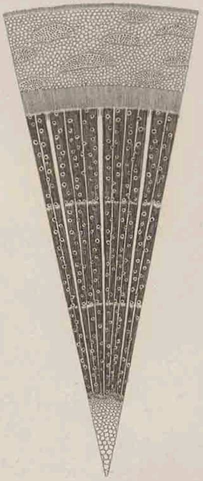
7. Hazel.



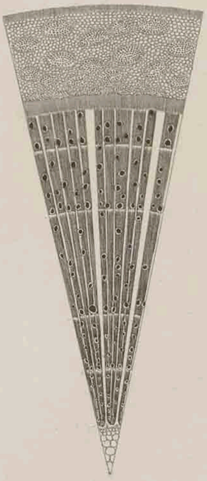
8. Oak.



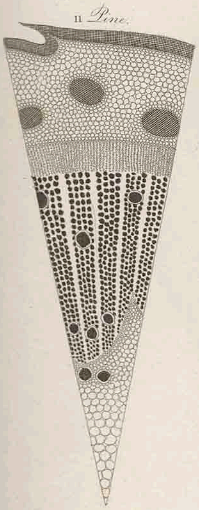
9. Pear.



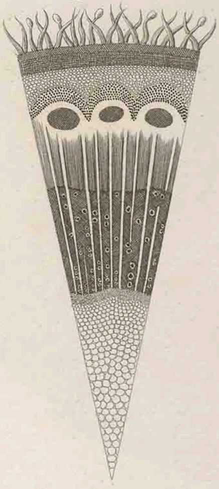
10. Plum.



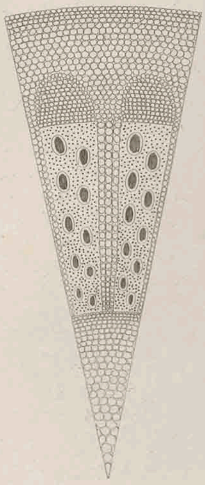
11. Pine.



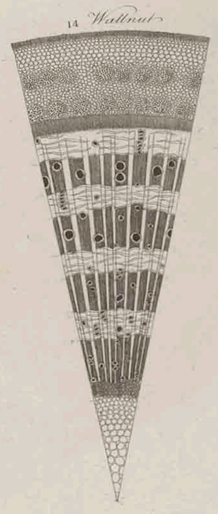
12. Sumach.



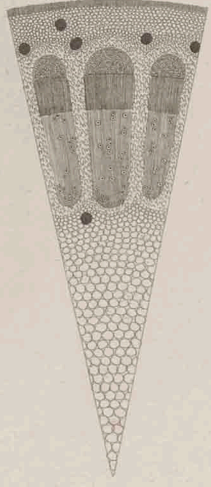
13. Vine.



14. Wallnut.



15. Wormwood Stalk.



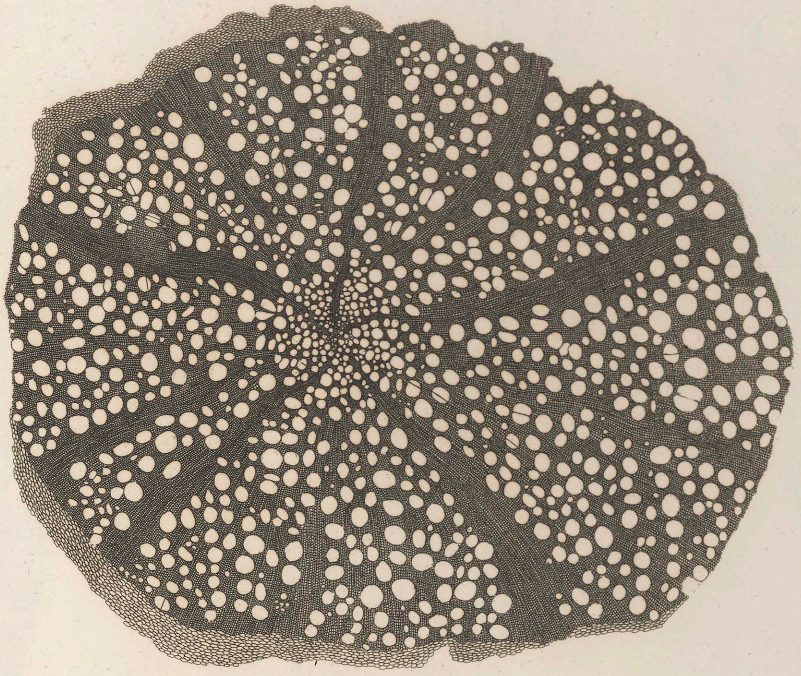
The natural size.

Warner sculp.

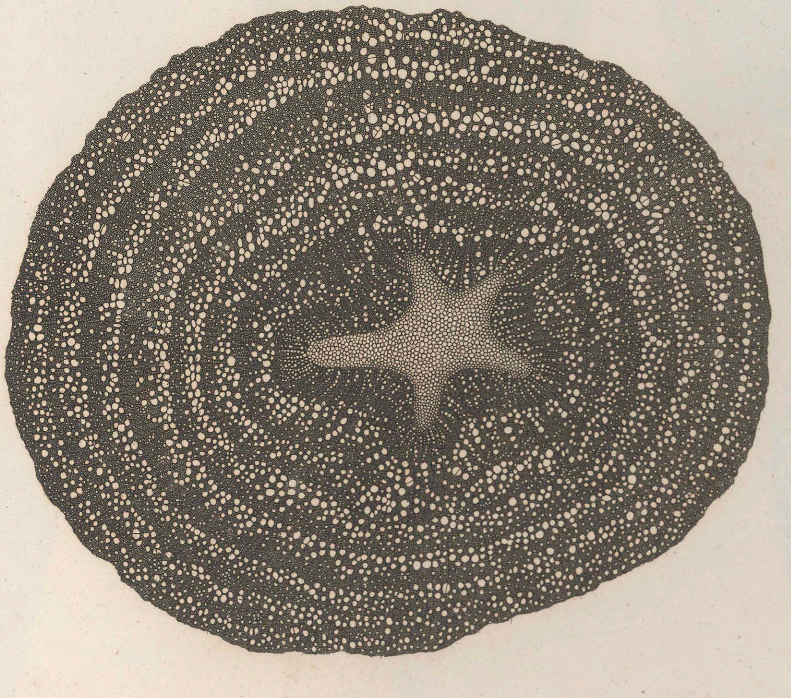
London, Published May 1. 1798, for Dr. Thornton.

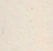
Anatomy of the Oak.

THE ROOT.



THE BRANCH.



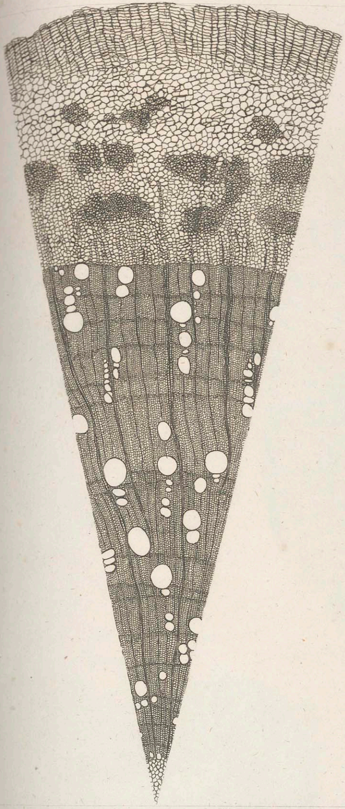


Warner del. et sculp.

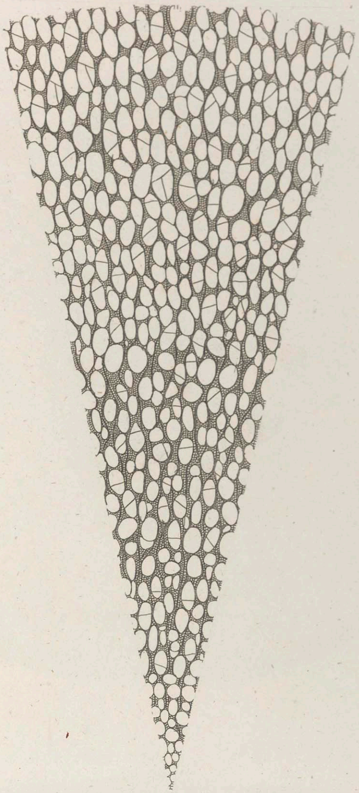
London, Published by Dr. Thornton, Feby. 1, 1803.

These Roots still more magnified to shew more clearly the Vegetable Organization.

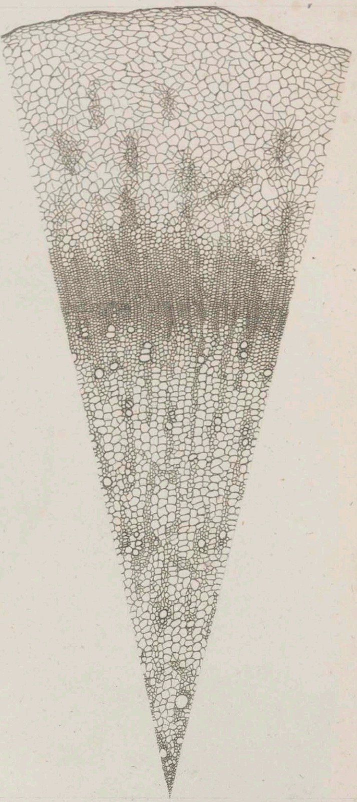
1. ASH.



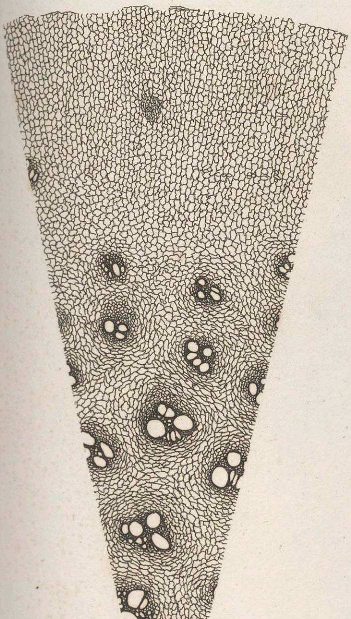
2. ASPIN.



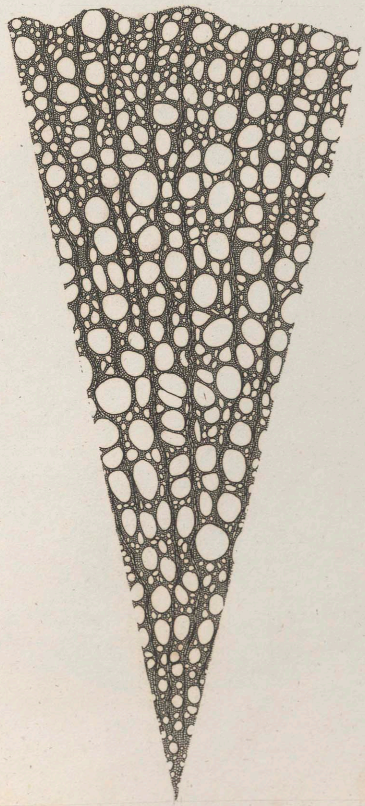
3. CARROT.



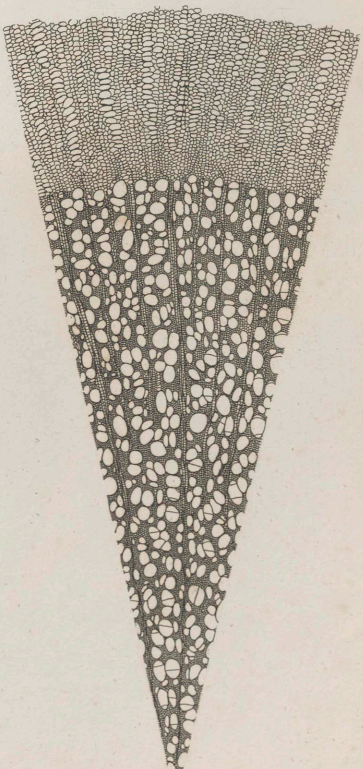
4. CHINA ROOT.*



5. ELM.



6. ELDER.



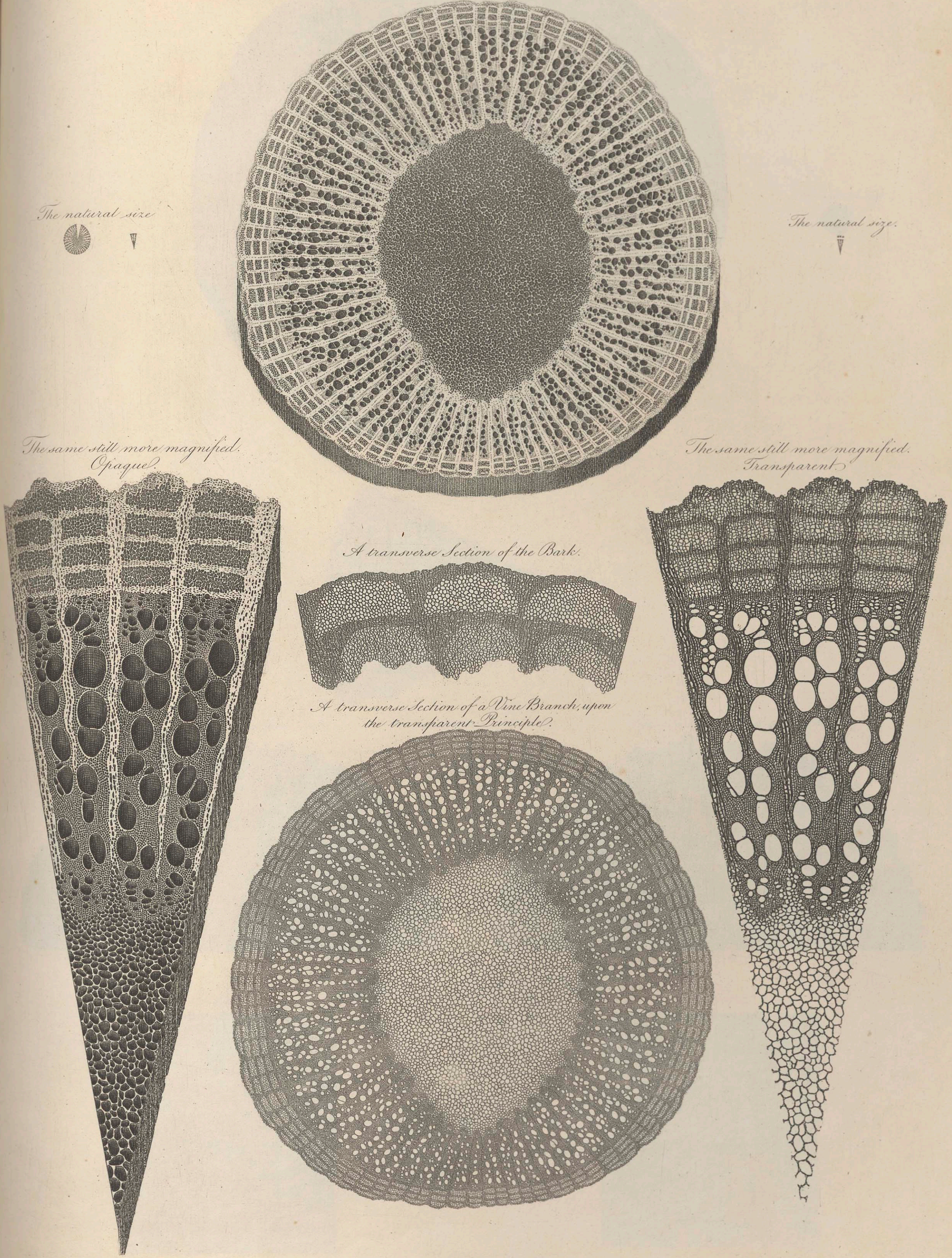
Custine ſecavit.

* Certainly the China Smilax.

Warner del. et ſculp.

Publish'd by Dr. Thornton August 1 1800.

The Organization of the Grape-Vine as seen through the Microscope,
With a view to shew its true Structure, and correct the Imperfections of former Representations.



A transverse Section of a Vine Branch, upon the opaque Principle.
No Bark.

The natural size

The natural size.

The same still more magnified.
Opaque.

The same still more magnified.
Transparent.

A transverse Section of the Bark.

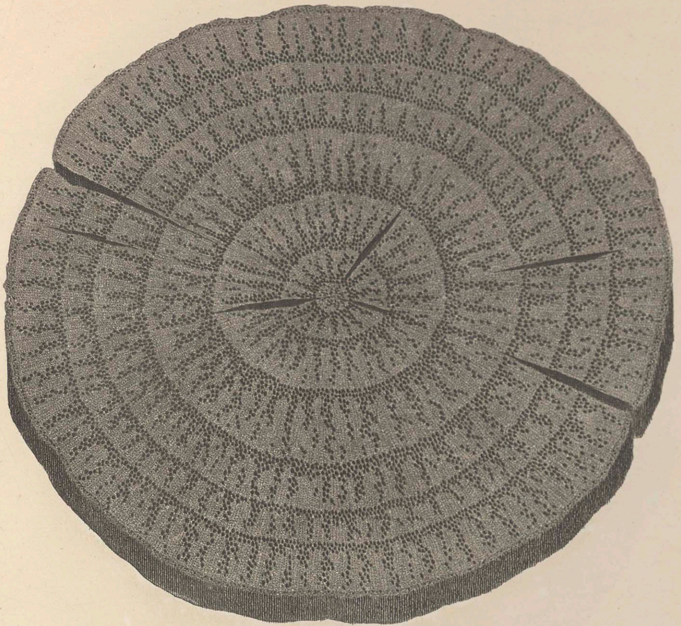
A transverse Section of a Vine Branch, upon the transparent Principle.

London, Published by Dr. Thornton, Nov. 1. 1799.

Warner del. et sculp.

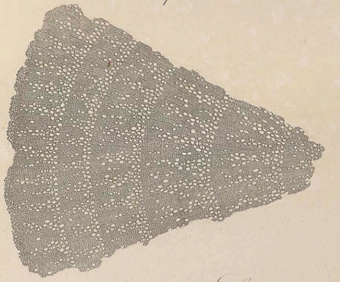
The Organization of Charcoal & Cork; from Hook's Micrographia.

Charcoal as seen through a Microscope.



The natural size.

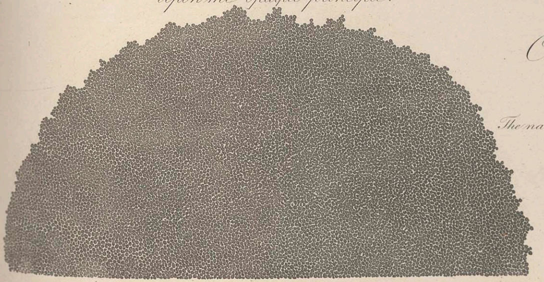
A thin slice of the same.



The natural size.

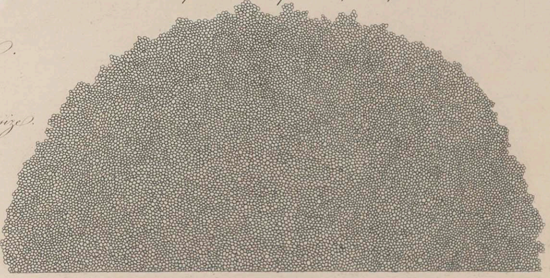
Transverse Sections of Cork.

Upon the opaque principle.



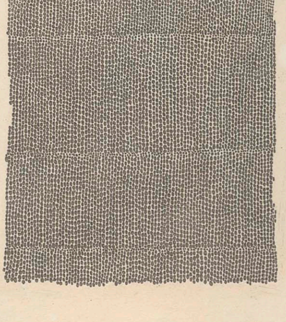
The natural size.

Upon the transparent principle.



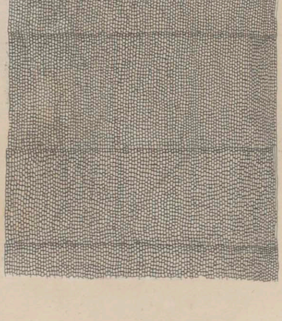
Longitudinal Sections of Cork.

Opaque.



The natural size.

Transparent.

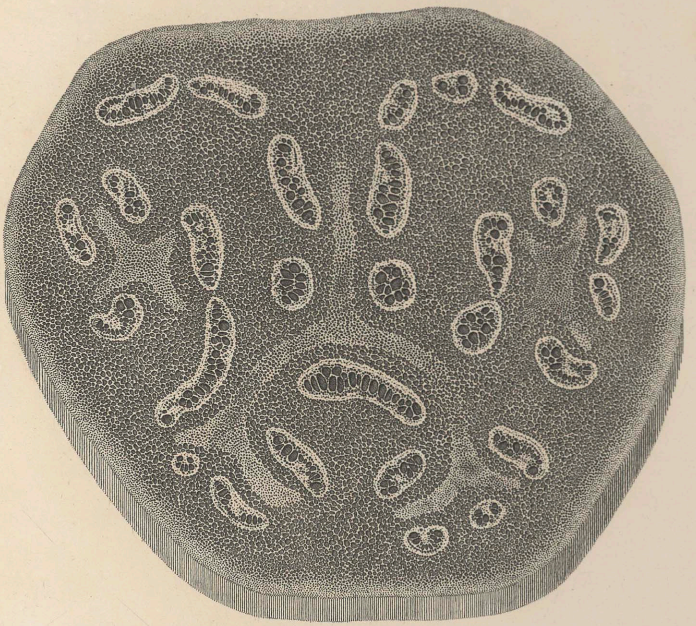


London, Published by Dr. Thornton, Bennet Street, St. James May 1798.

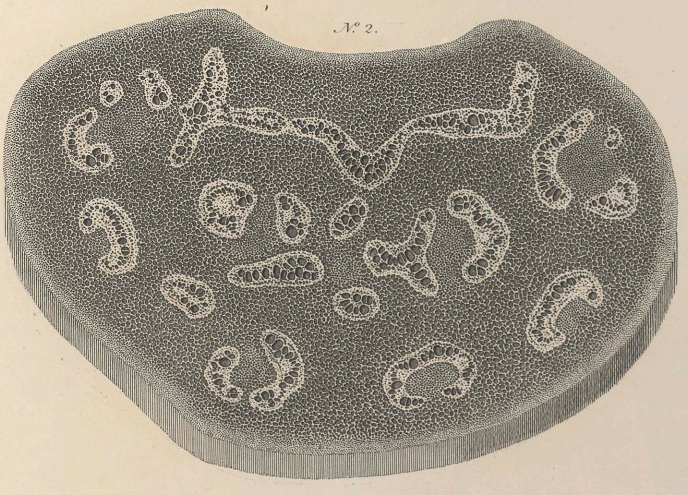
Warner delint. et sculpt.

Sections of Ferns as seen through a Microscope, upon the Opaque Principle.

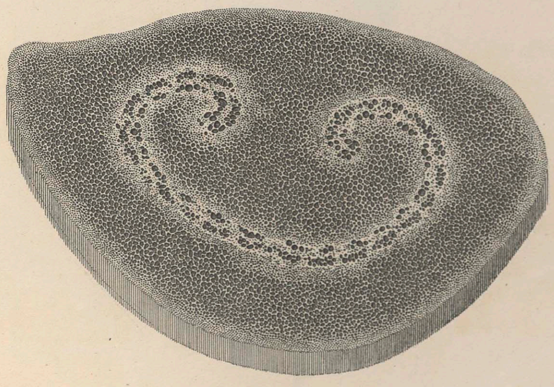
N°. 1.

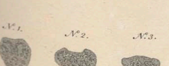


N°. 2.



N°. 3.





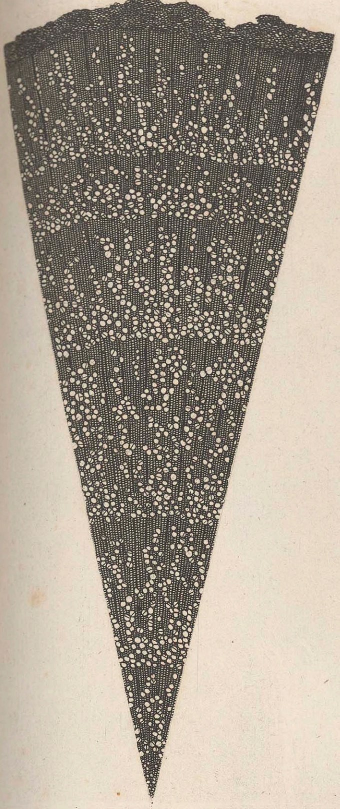
Ferns of their natural size.

London Published by Dr. Thornton, Bennet Street, St. James, May. 1798.

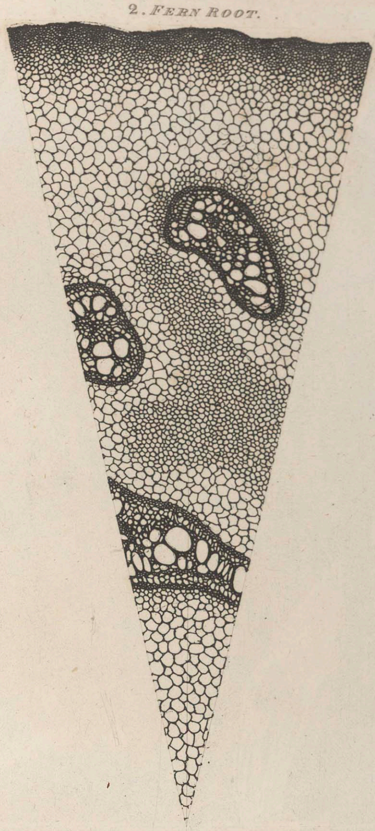
The Same still more magnified, to shew more clearly the Vegetable Organization.

Transparent Views.

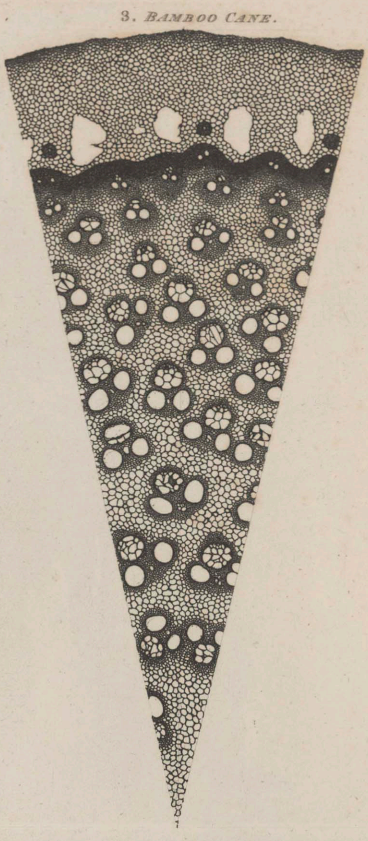
1. CHARCOAL.



2. FERN ROOT.

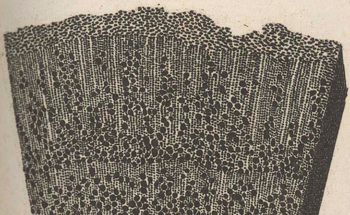


3. BAMBOO CANE.

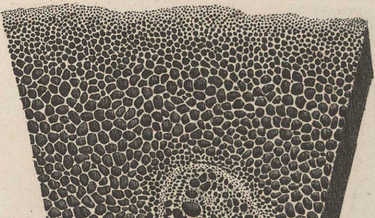


Opaque Views

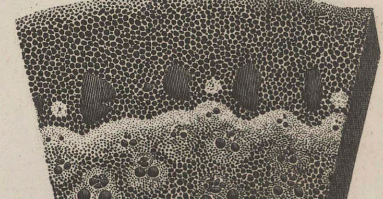
4. CHARCOAL.



5. FERN ROOT.



6. BAMBOO CANE.

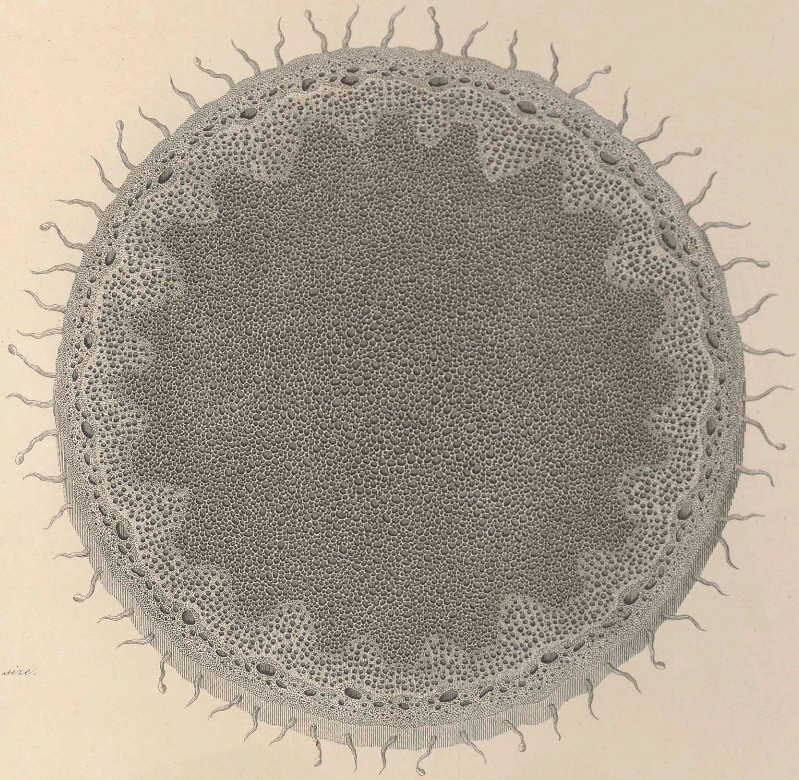


Warner del. et sculp.

London. Published May 1. 1800. by Dr. Thornton.

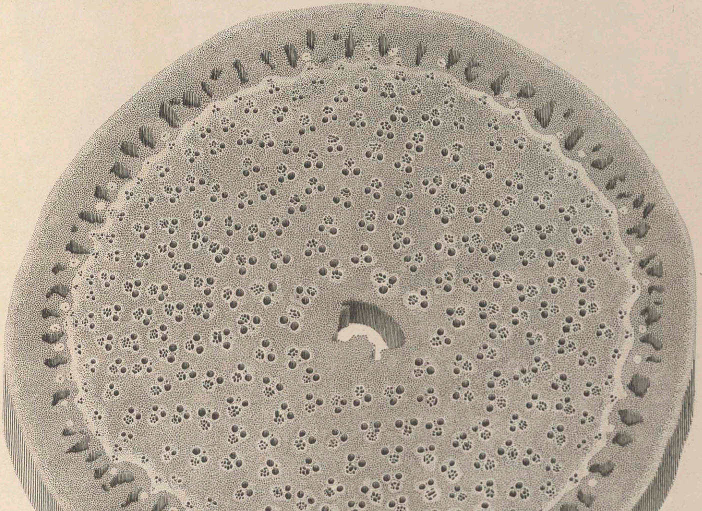
Transverse Sections as seen through a Microscope, upon the Opaque Principle.

SUMACH.



The natural size.

BAMBOO CANE.



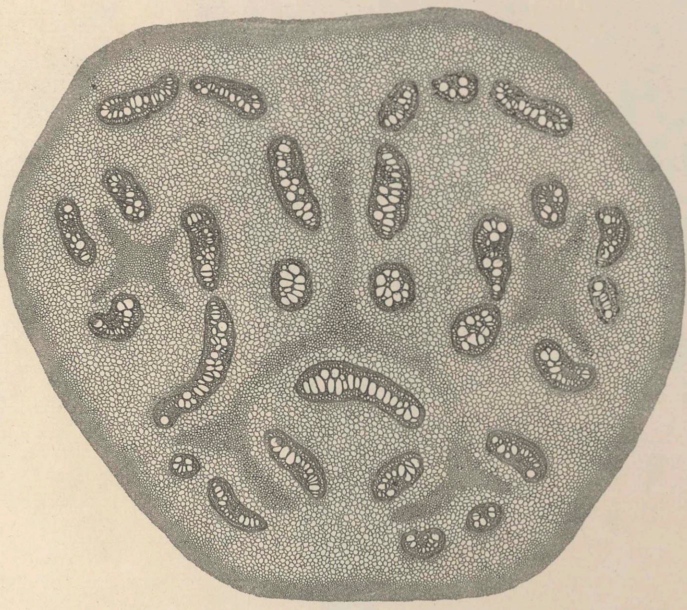
The natural size.

Warner delin.t et sculp.t

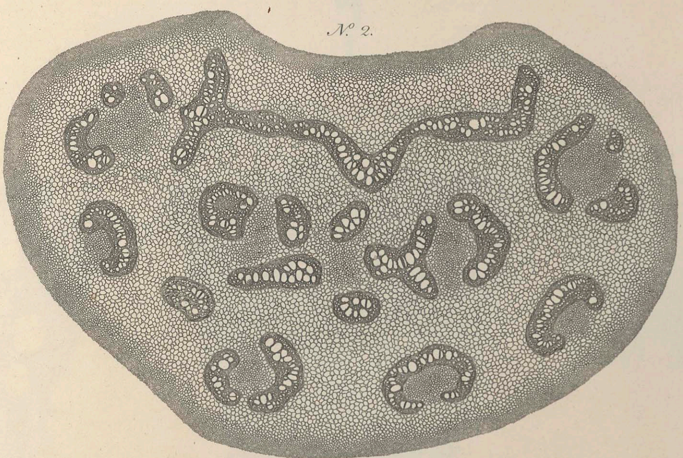
London. Published by Dr. Thornton, Duke Street, Grosvenor Square, Jan.y 1799.

Transverse Sections of Ferns as seen through a Microscope, upon the Transparent Principle.

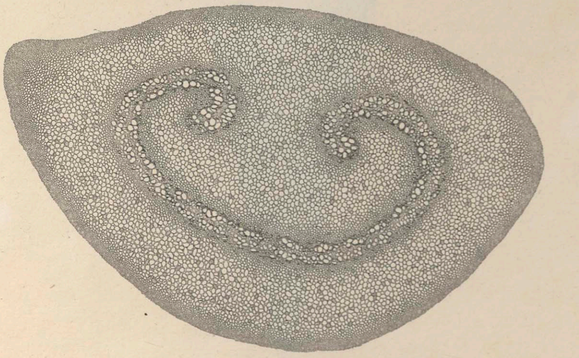
No. 1.

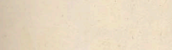


No. 2.



No. 3.





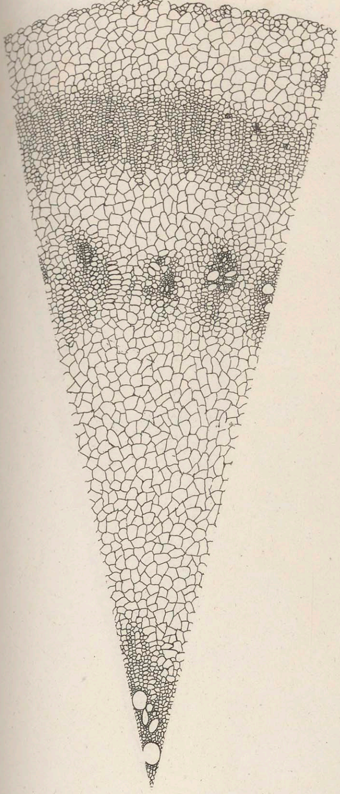
Stalks of Ferns of their natural size.

Warner delin.t et sculp.t

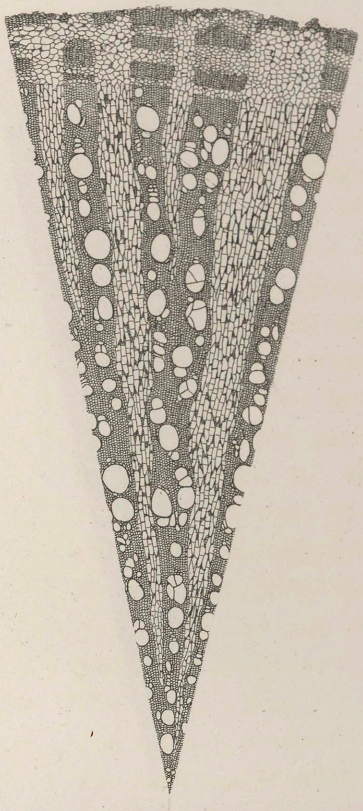
London. Published by Dr. Thornton Duke Street Grosvenor Square Jan.y 1799.

These Roots still more magnified to shew the Vegetable organization.

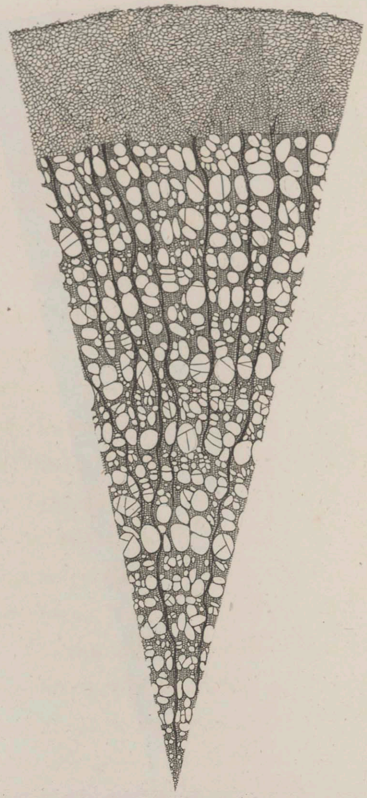
7. FENNEL.*



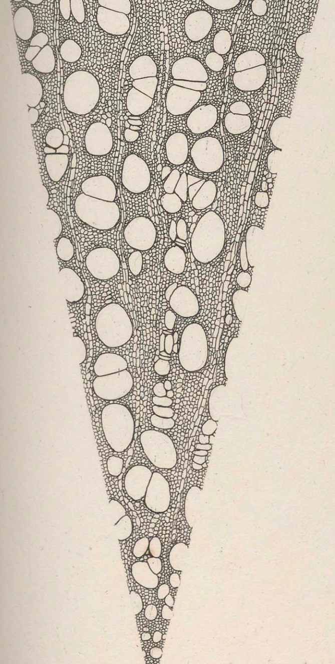
8. GRAPE VINE.*



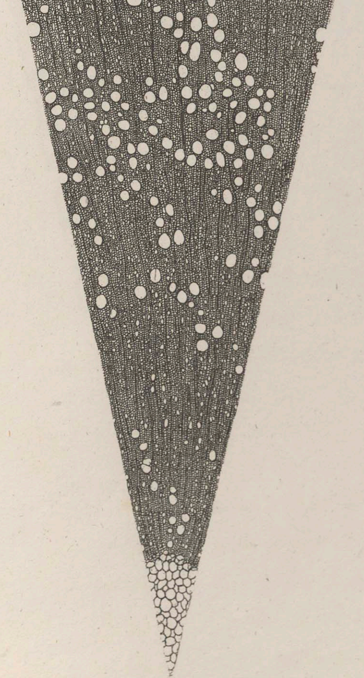
9. LIME.*



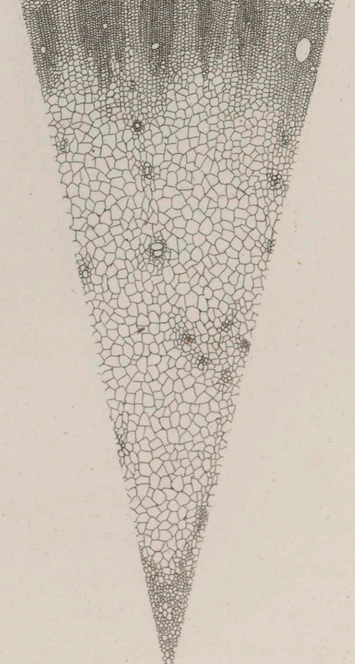
10. MULBERRY.*



11. OAK.*



12. AMERICAN NIGHTSHADE.*



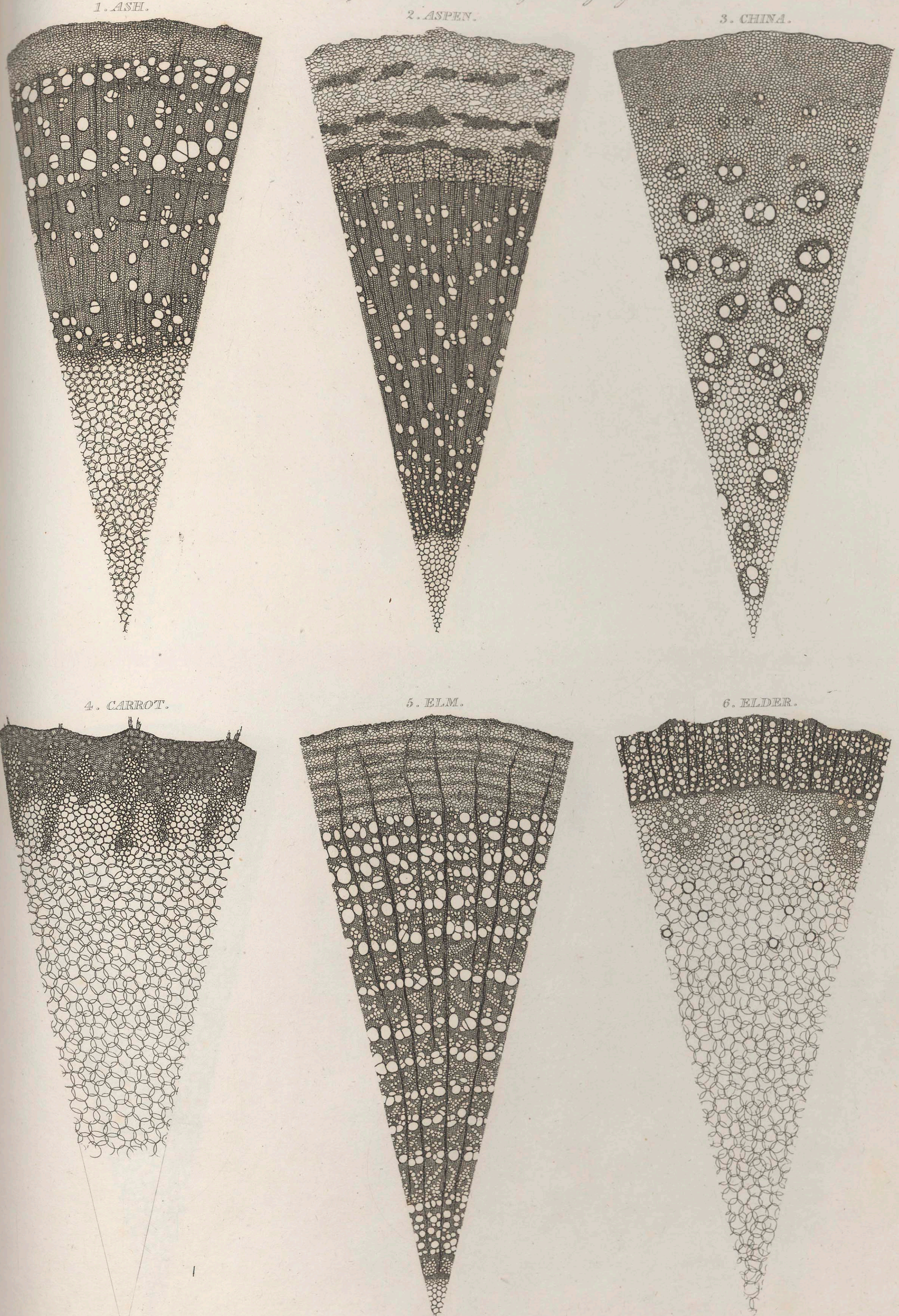
* *The Asterick is put here to descriminate the numbers from the next plate, which being printed first from oversight has been wrong numbered.*

Cumine secavit.

Warner del. et sculp.

London. Published May 2.1803, by Dr. Thornton.

These Stems still more magnified to shew the vegetable organization.



1. ASH.

2. ASPEN.

3. CHINA.

4. CARROT.

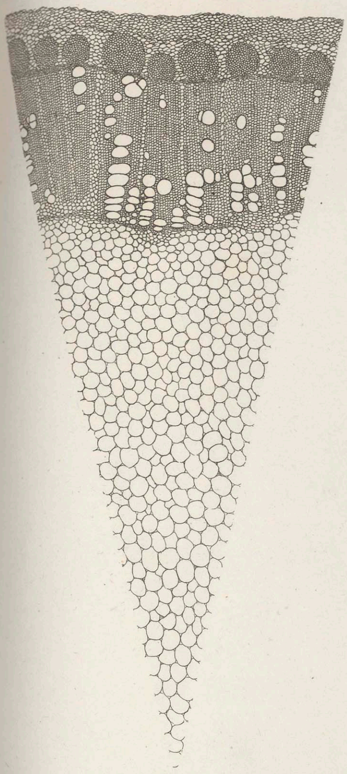
5. ELM.

6. ELDER.

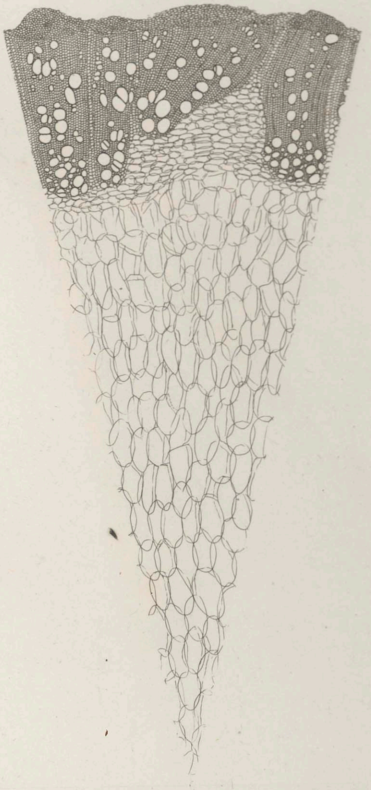
London, Published by Dr. Thornton. June 1, 1803.

Warner del. et sculp.

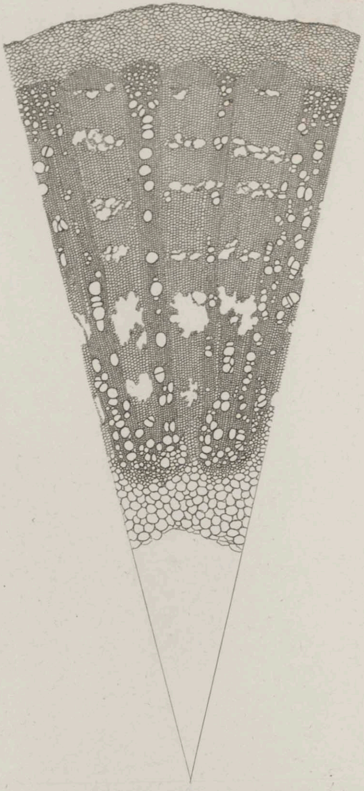
These Stems still more magnified to shew the Vegetable organization.



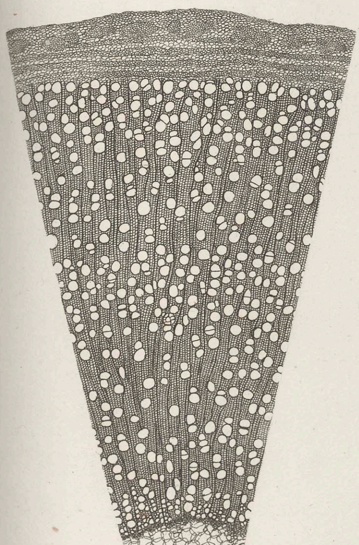
PARSLEY.



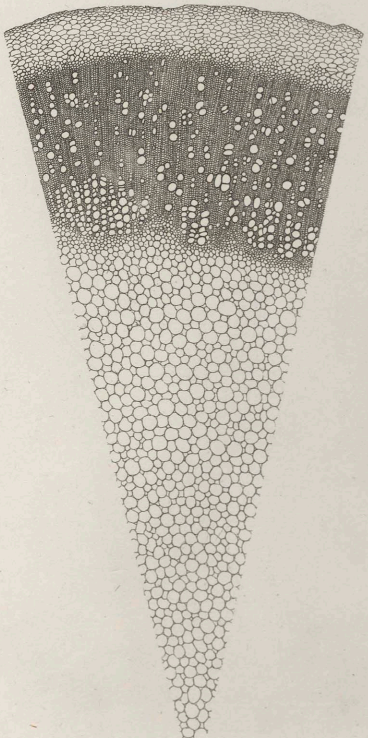
SUN-FLOWER.



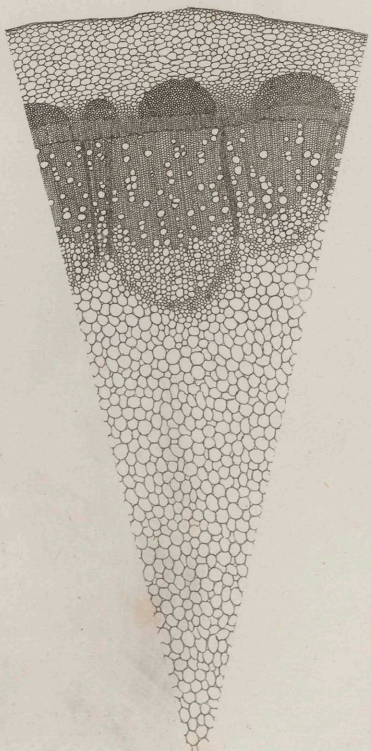
STINGING-NETTLE.



WILLOW.



TEASEL.



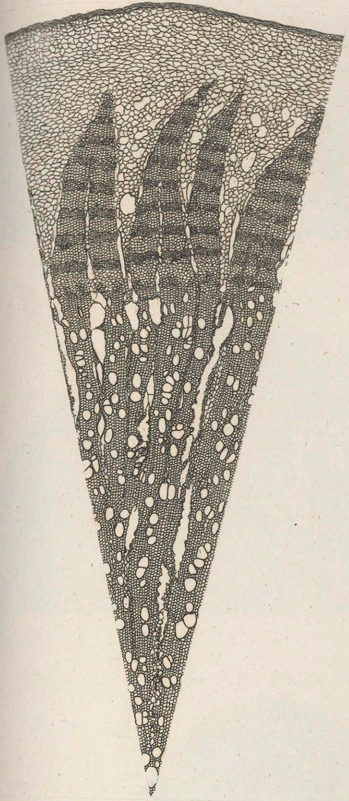
WORMWOOD.

Warner del. et sculp.

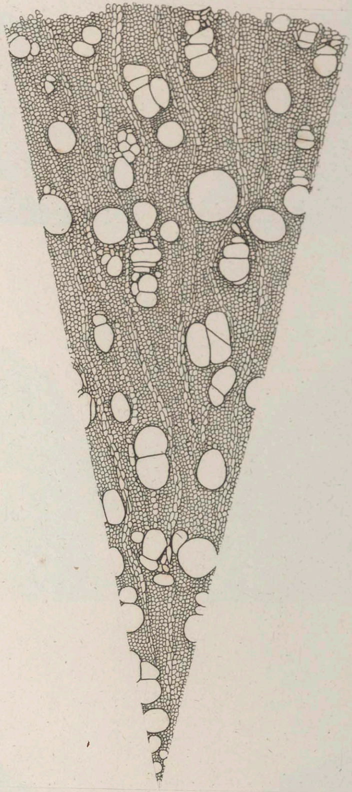
London. Published by Dr. Thornton June 1.1803.

These still more magnified in order to shew more clearly the Anatomy of the Root.

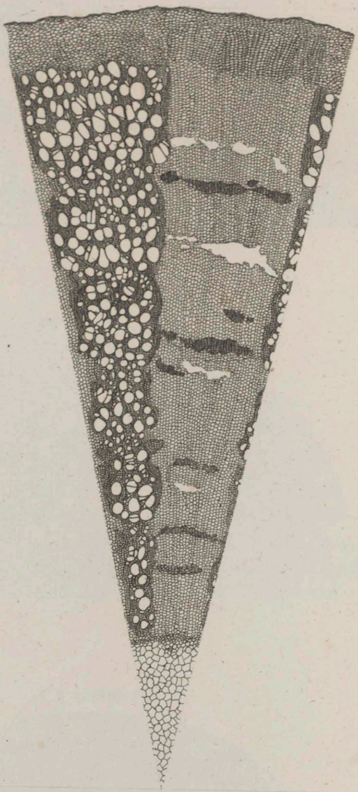
7. *PARSLEY ROOT.*



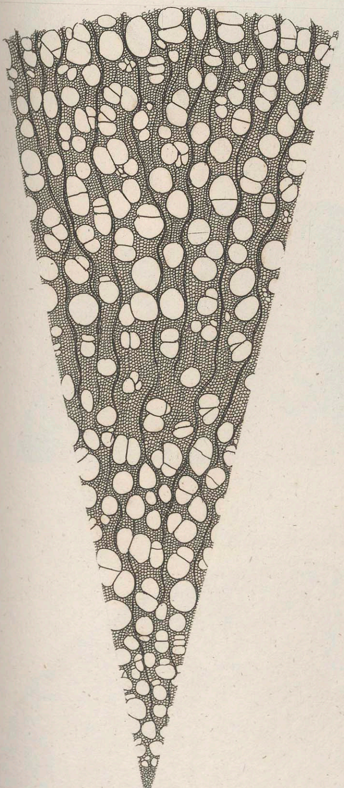
8. *SUNFLOWER ROOT.*



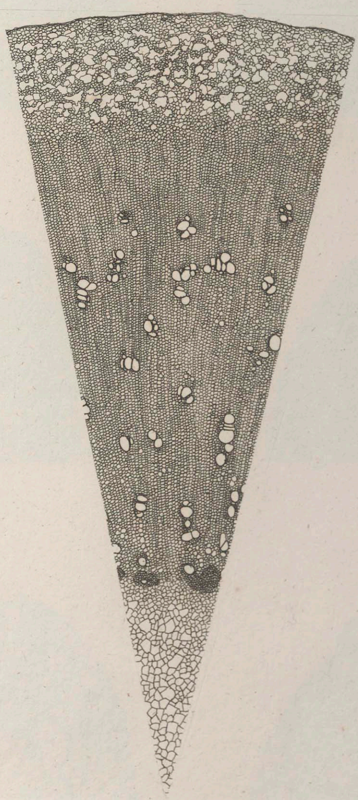
9. *STINGING NETTLE ROOT.*



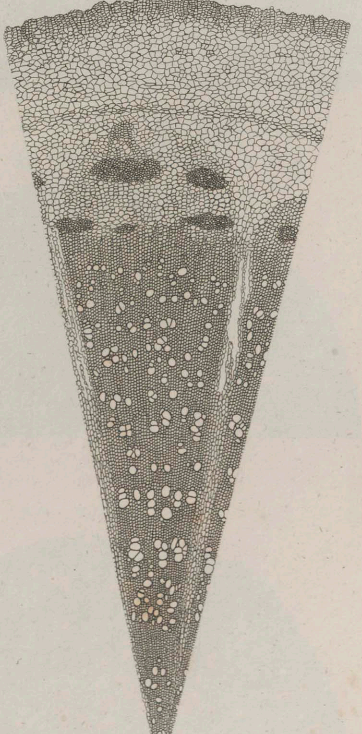
10. *WILLOW ROOT.*



11. *TEASEL ROOT.*



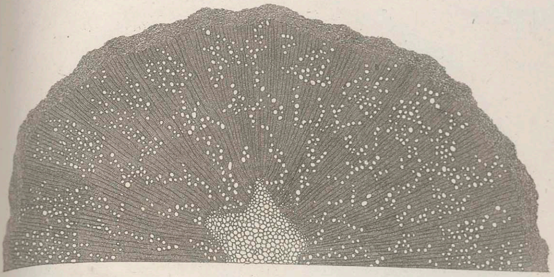
12. *WORMWOOD ROOT.*



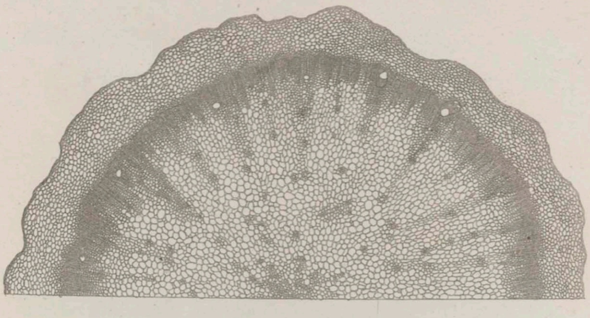
Warner del. et ſculp.

London, Published October 21. 1800, by Dr. Thornton.

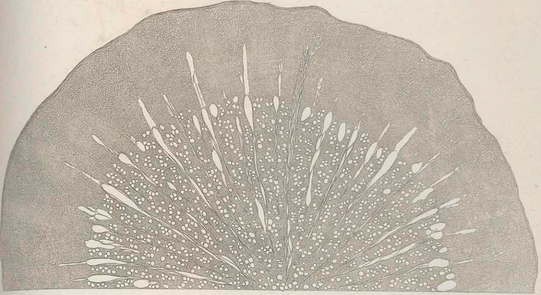
11. OAK.



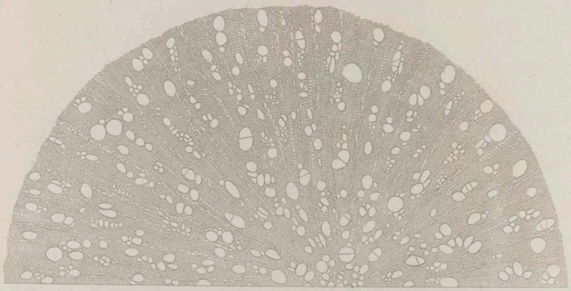
12. AMERICAN NIGHTSHADE.



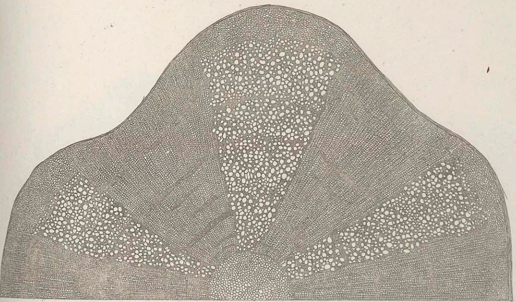
13. PARSLEY.



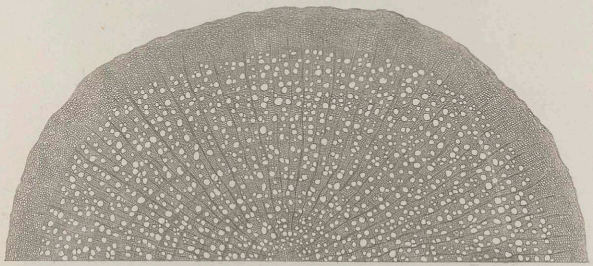
14. SUN-FLOWER.



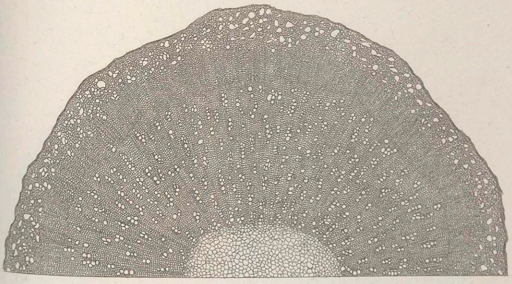
15. NETTLE.



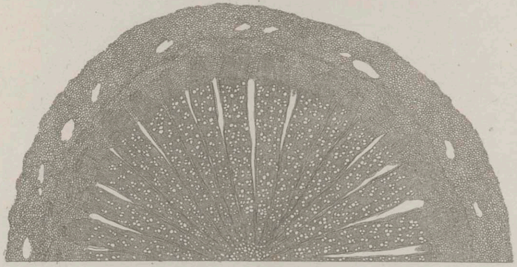
16. SYCAMORE.



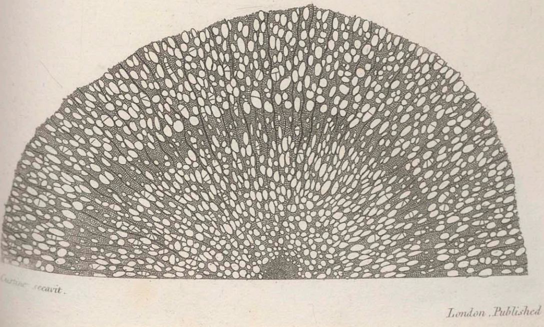
17. TEASEL.



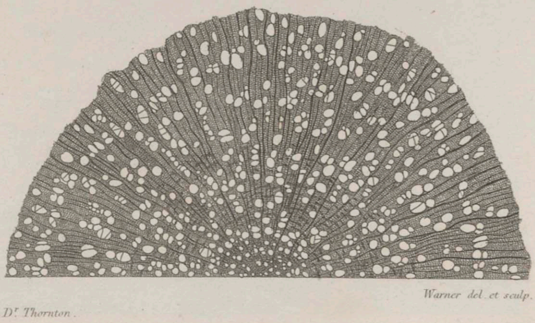
18. WORMWOOD.



19. WILLOW.



20. WALNUT.



Curtine secavit.

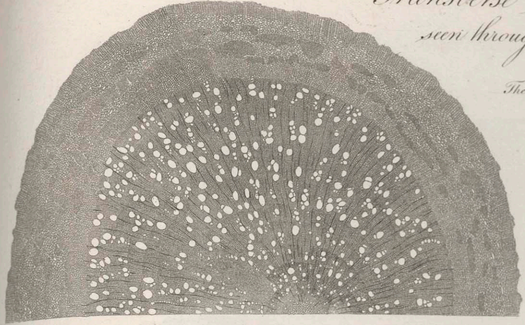
Warner del. et sculp.

London, Published May 2 1803, by Dr. Thornton.

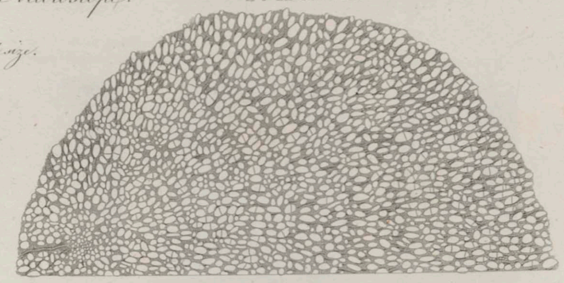
Transverse Sections of Roots seen through the Microscope.

The natural size.

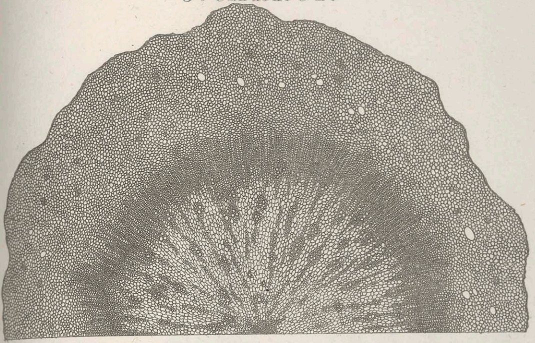
1. ASH.



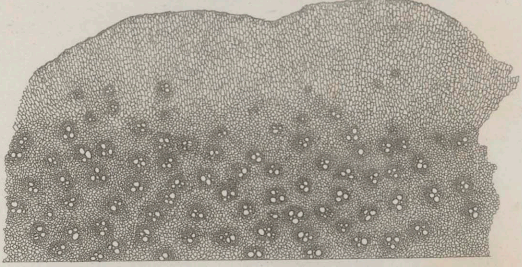
2. ASPEN.



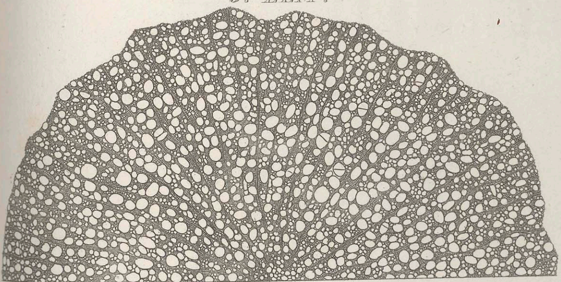
3. CARROT.



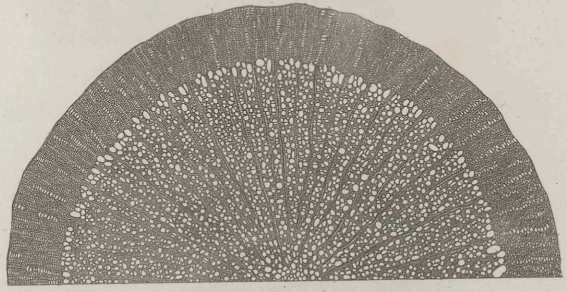
4. CHINA ROOT.



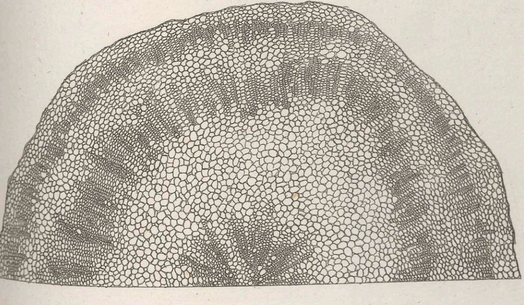
5. ELM.



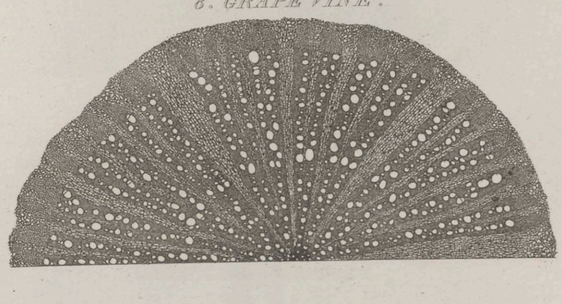
6. ELDER.



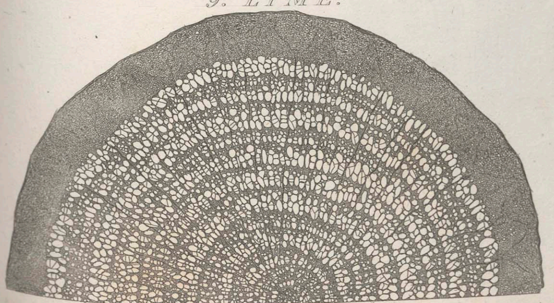
7. FENNEL.



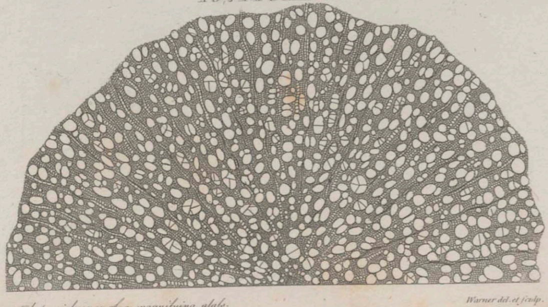
8. GRAPE VINE.



9. LIME.



10. MULBERRY.



Warner del. et sculp.

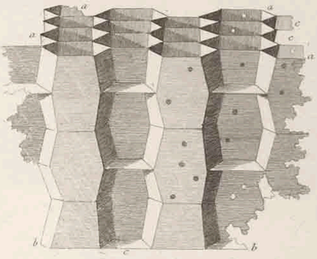
N.B. To see the excellency of these plates the observer is requested to make use of a magnifying glaſs.

Publiſhed Jany 1 1799, by Dr Thornton, Duke Street, Grosvenor Square.

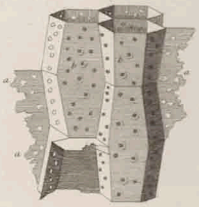
Vegetable Anatomy

From the Original Paintings in the Museum of Natural History at Paris

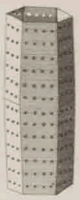
1. Cellular Tiſsue regular & somewhat porous.



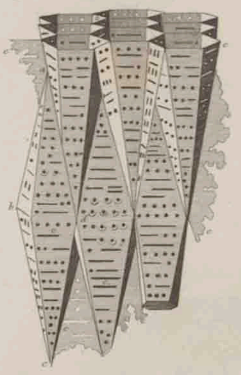
2. D^o. more long & porous.



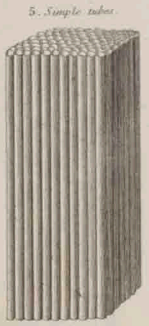
3. D^o. still Longer with regular transverse pores.



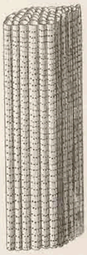
4. D^o. Pyramidal with pores & slits.



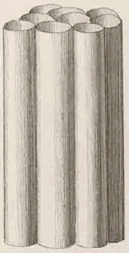
5. Simple tubes.



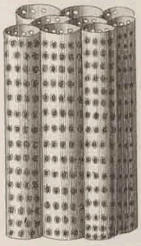
6. Tubes with transverse pores.



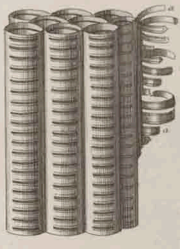
7. Very large Tubes, simple.



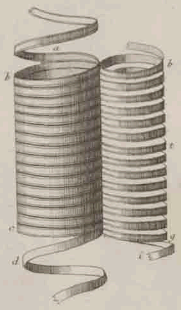
8. D^o. with pores.



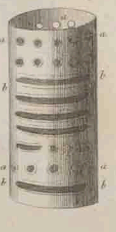
9. D^o. with slits.



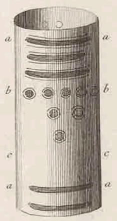
10. Real Trachea.



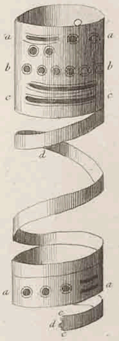
11. Tube compound.



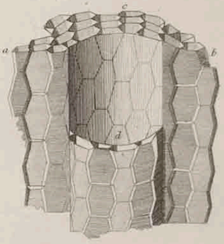
12. D^o. leſs compound.



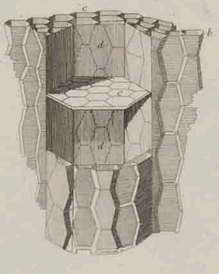
13. D^o. compound & with Trachea.


a
a
b
b
c
c
d
a
a
d
c

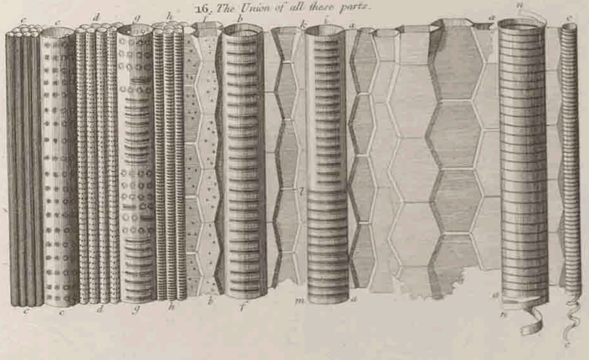
14. Cellular Tiſsue broken so as to show a Gap.



15. D^o. the Gap or hollow leſs perfect.



16. The Union of all these parts.


c
c
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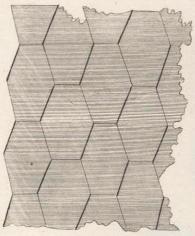
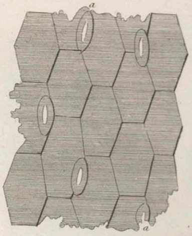
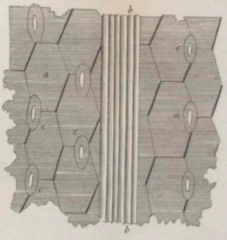
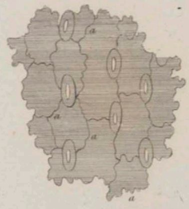
London, Published by D^r. Thornton, Feby. 1. 1805.

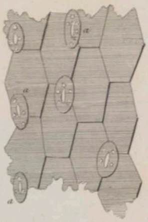
The Vegetable Anatomy continued

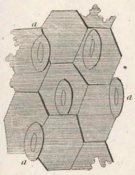

17. Epiderm a Cellular texture.

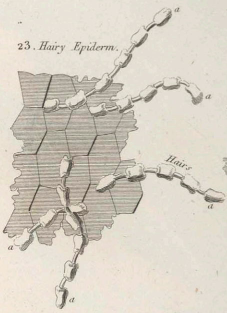

18. Dº. with oblong pores.

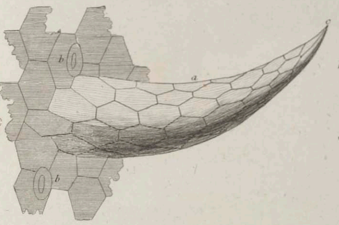

19. Dº. compound with simple tubes.

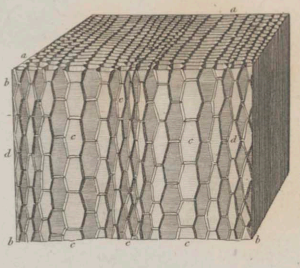

20. The same as Fig. 18 with undulated sides.

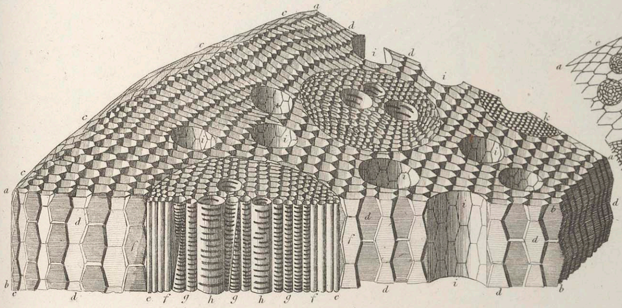

21. Dº. with tubes within tubes.

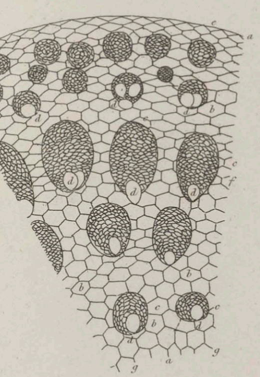

22. Dº. with central tubes stopt.

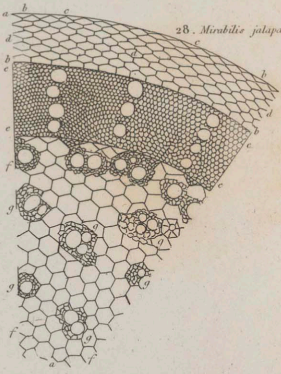

23. Hairy Epiderm.

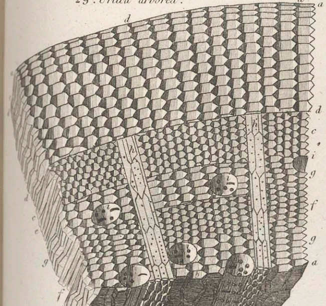

24. Horny Epiderm.

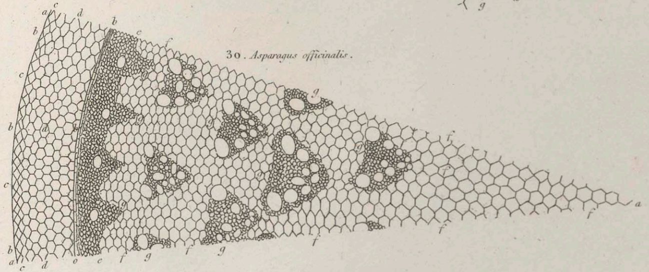

25. Fucus fimbriatus.

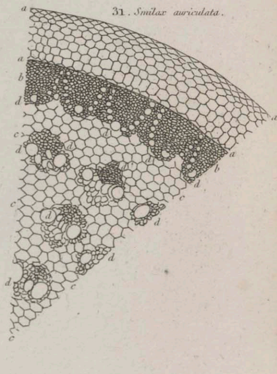

26. Acrostichum aureum.

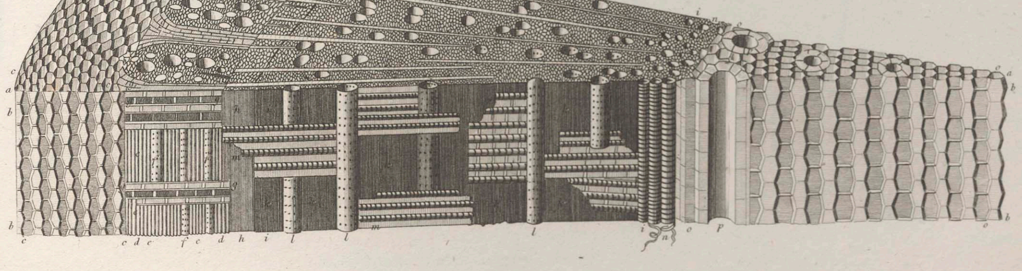

27. Calamus.


28. Mirabilis jalapa.


29. Urtica arborea.


30. Asparagus officinalis.


31. Smilax auriculata.

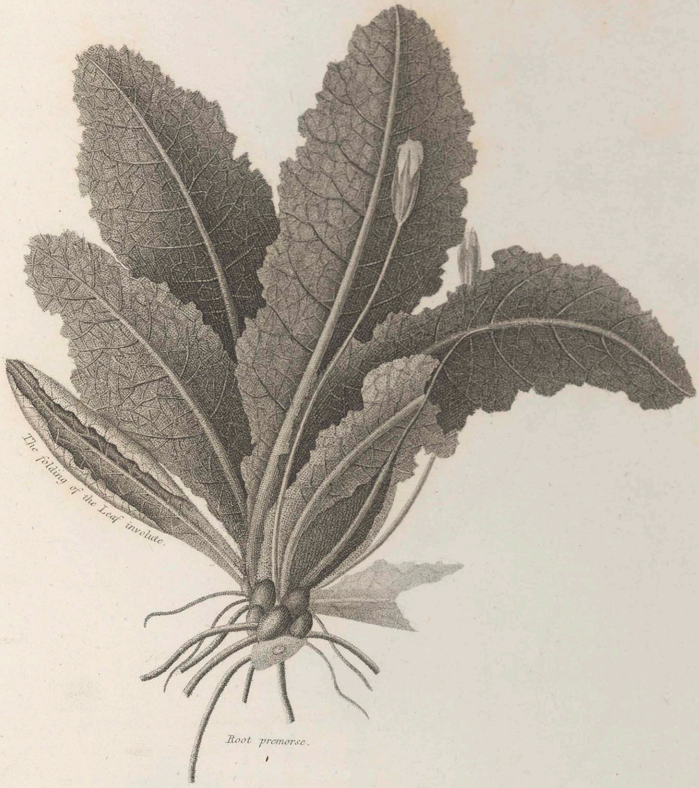

32. Sambucus nigra.

pinx.ᵗ

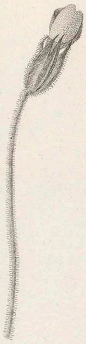
Mazel sculp

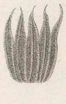
London, Published by Dr. Thornton Feb.ʸ 1, 1805.

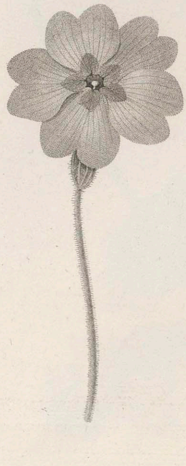
The Primrose.

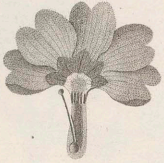

The folding of the Leaf involute.
Root premorse.

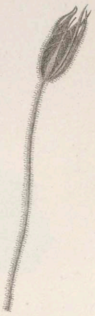
DISSECTION.


First Stage of the flower.


Calyx 5 tooth'd pentagonal


Flower of the Primrose.

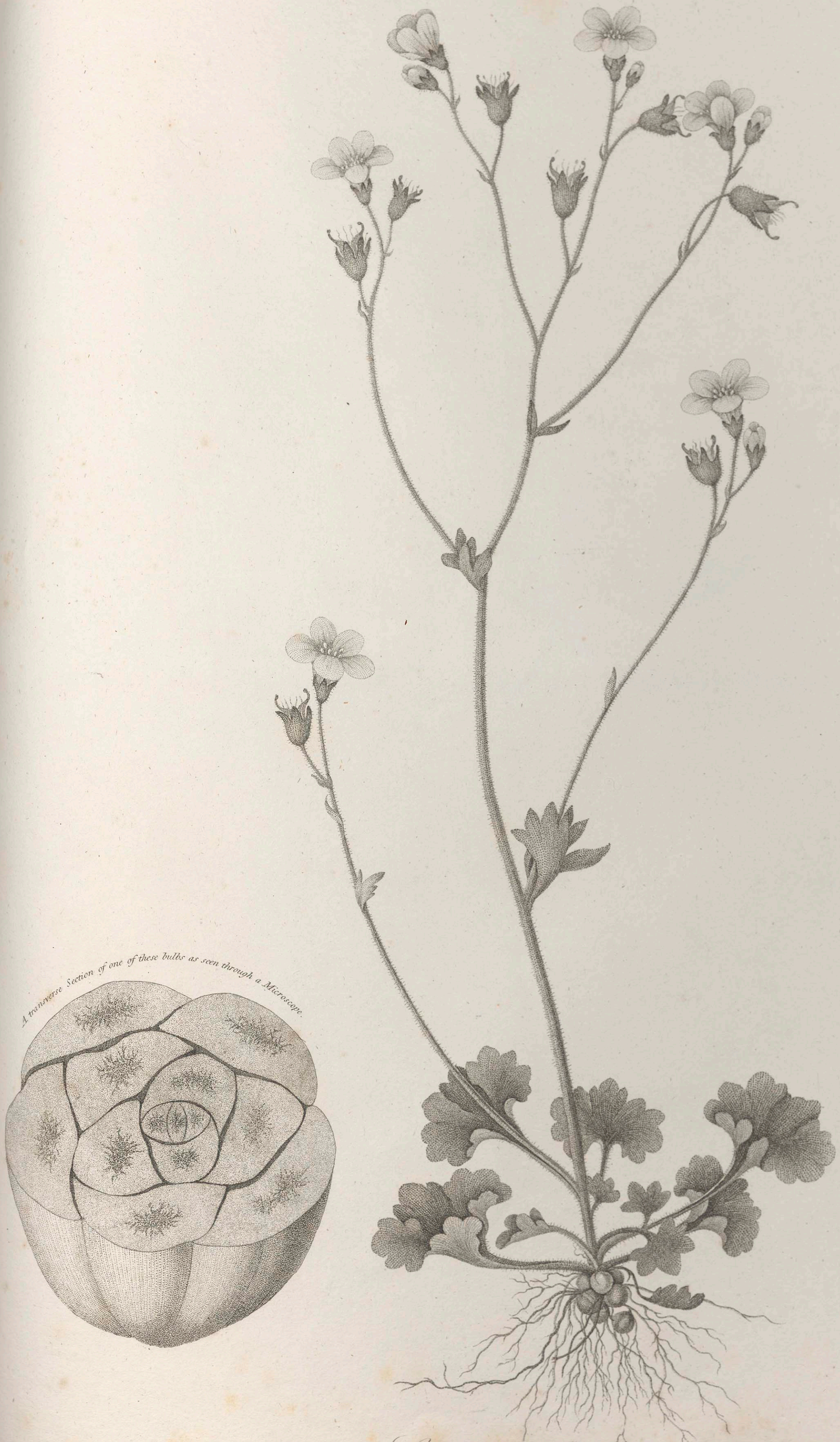

The five Stamina in the Tube of the Corolla, having scarce any filaments.


Calyx abiding, i.e. enclosing the mature seed-veſsel.

Henderson del.

Warner sculp.

London. Published by Dr. Thornton. June 1. 1803.

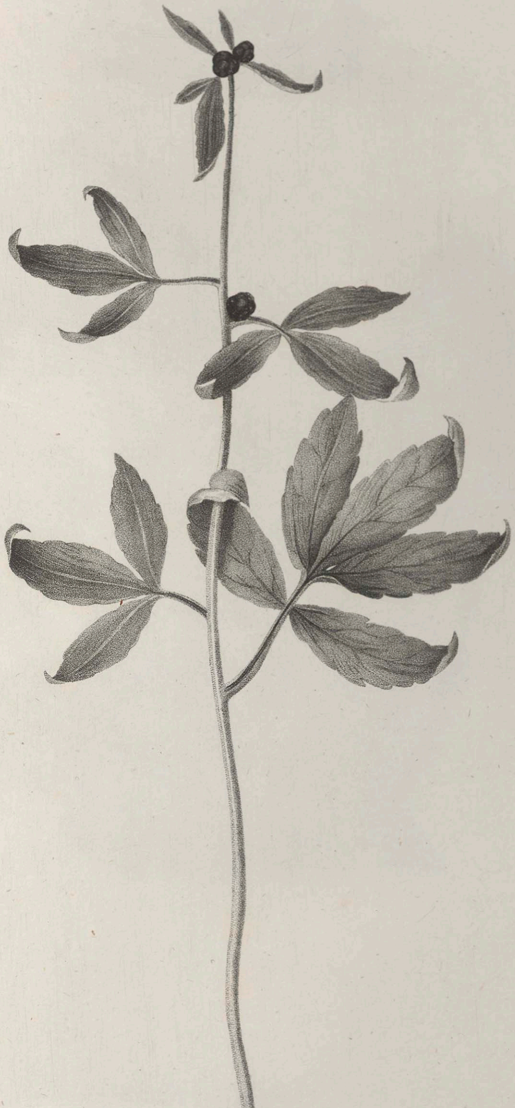

A transverse Section of one of these bulbs as seen through a Microscope.

Henderson delt.

Warner sculpt.

Granulated Saxifrage.

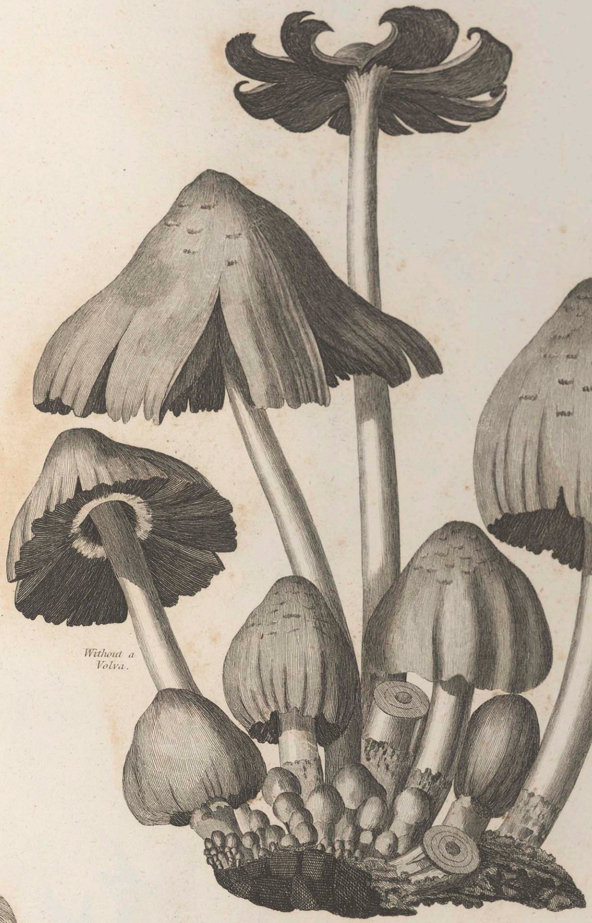
London Published Augt 1 1809 by Dr Thornton.



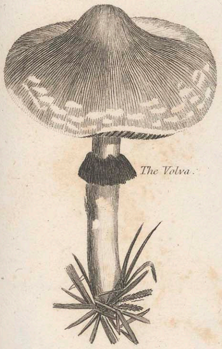
Bulb-bearing Dentaria.

Hopwood ſculp.

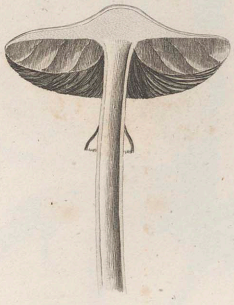
London, Published July 1. 1801, by Dr. Thornton, Hinde Street, Manchester Square.

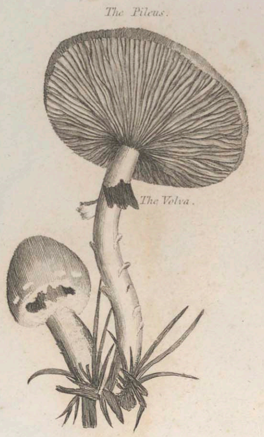

Without a Volva.

Agaricus ovatus.



A Section to shew the Gills.

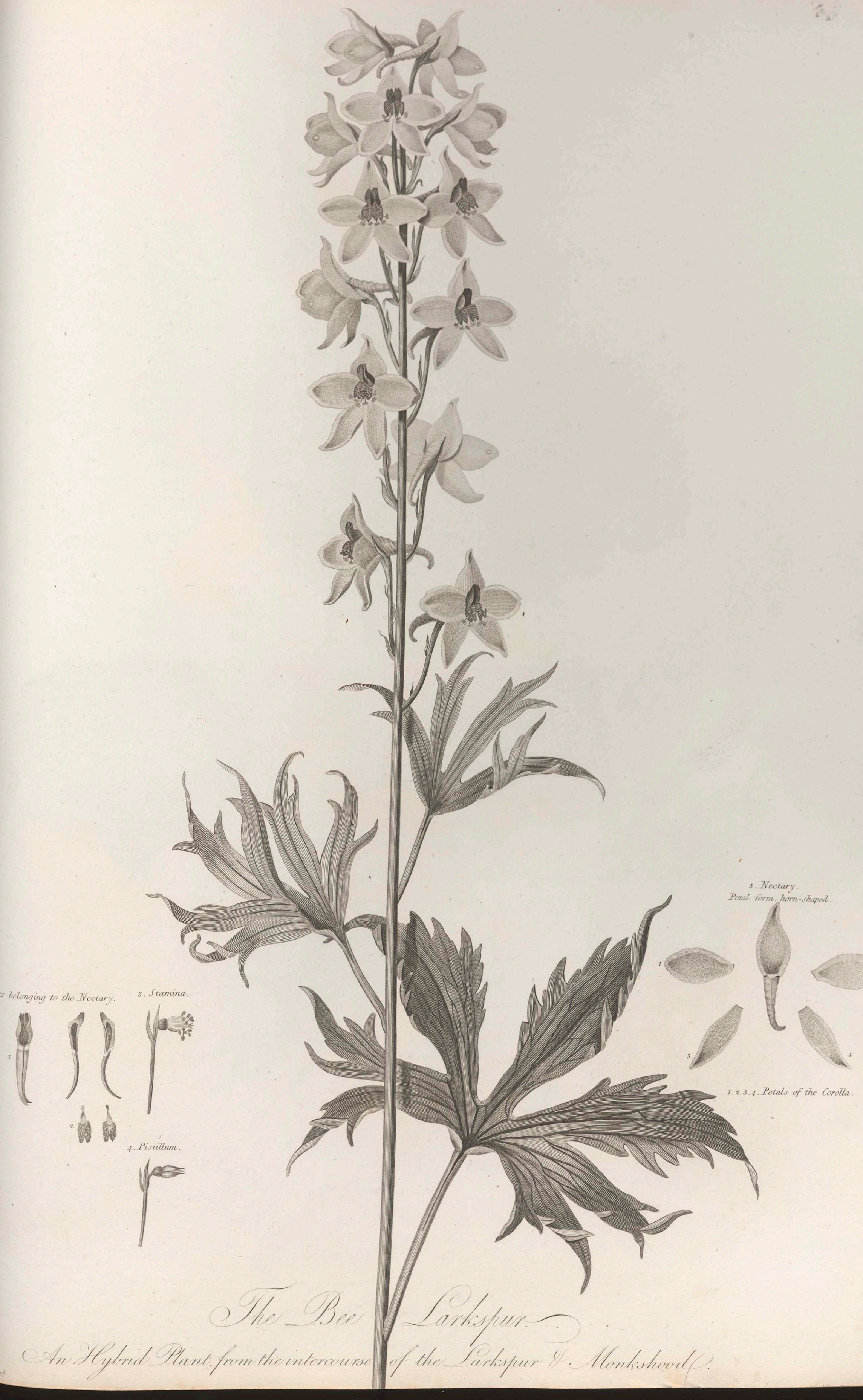



The Pileus.
The Volva.

Agaricus Æruginosus.

From M^r. Curtis's Flora Londinensis.

London Published by D^r. Thornton June 1 1803.


Parts belonging to the Nectary.
1
2
3. Stamina.
4. Pistillum.
5. Nectary.
Petal form, horn-shaped.
1
2
3
4
1.2.3.4. Petals of the Corolla.

The Bee Larkspur.

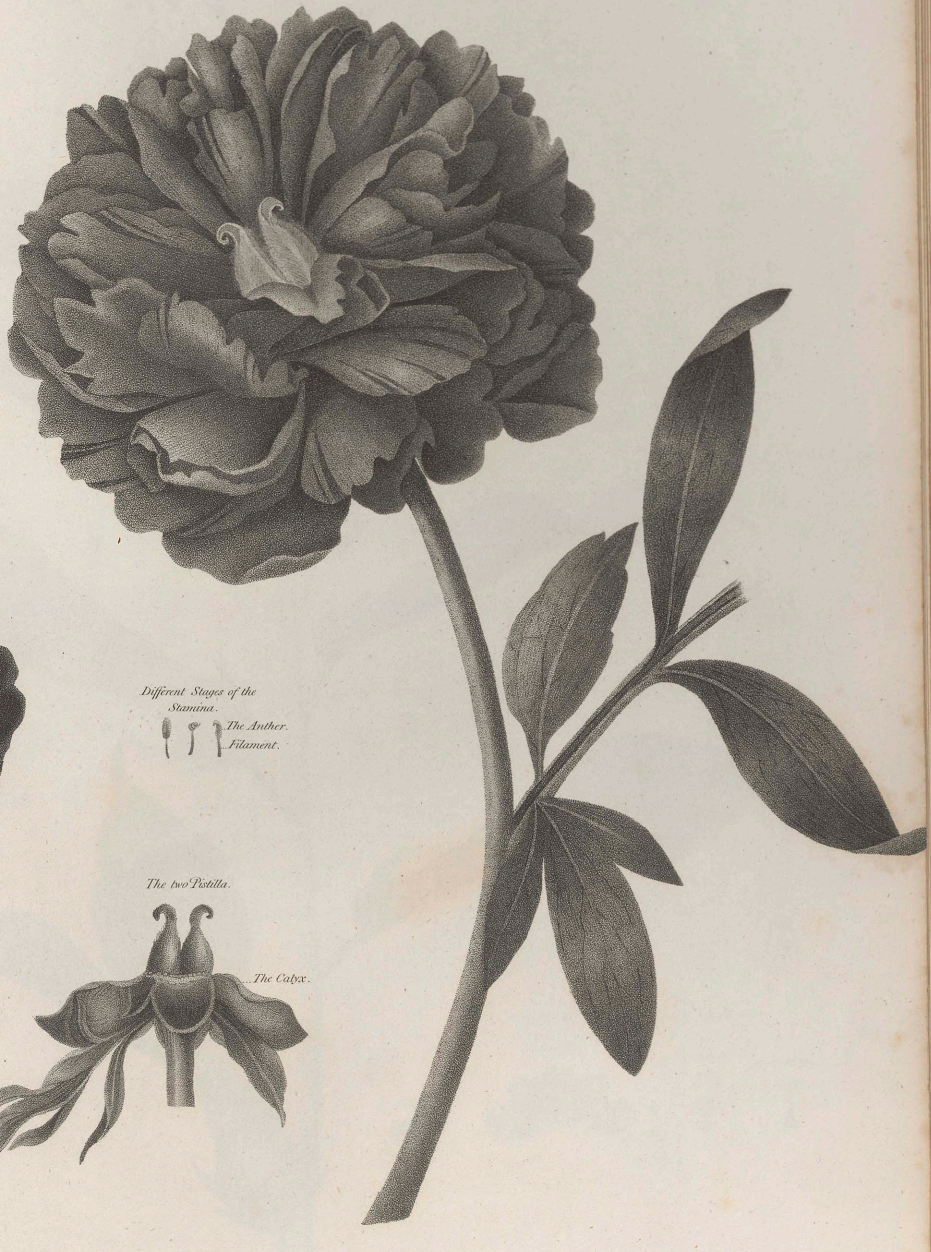
An Hybrid Plant, from the intercourse of the Larkspur & Monkshood.

pinxt.

Vegetable Monsters.

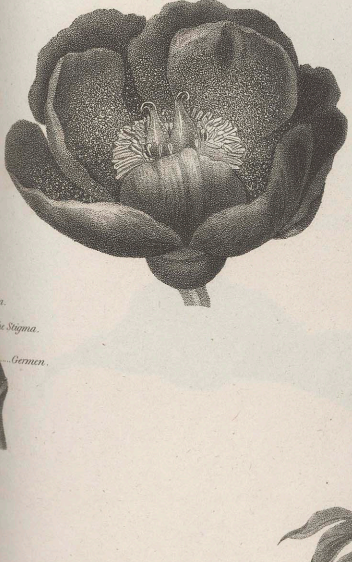
DOUBLE PIONY.

Petals multiplied so as to exclude all the Stamina.
Pistilla perfect only.



SINGLE PIONY.

Perfect Stamina & Pistilla.



Different Stages of the Stamina.

The Anther.
Filament.

Pistilla.

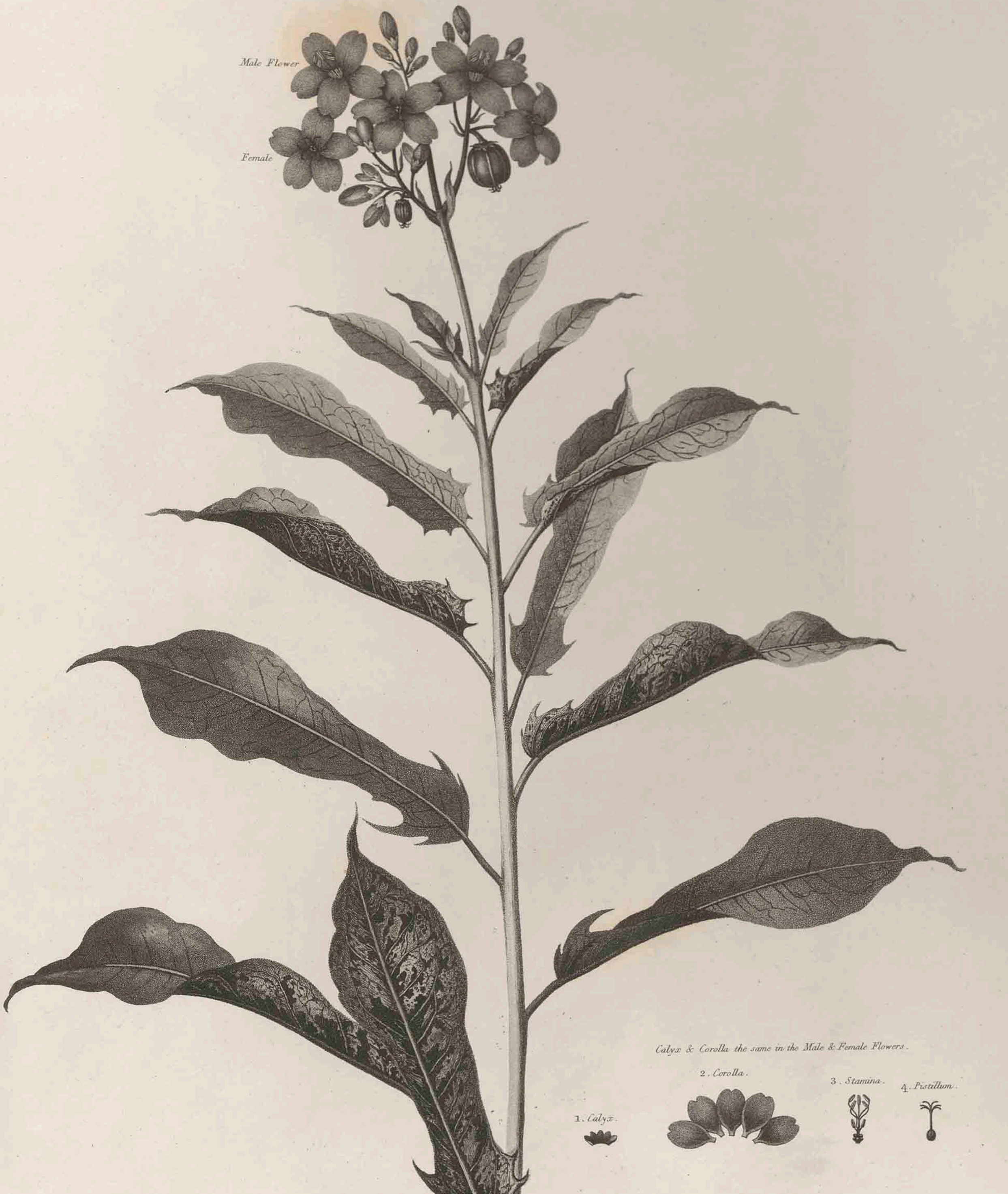
The Stigma.
Germen.

The two Pistilla.

del.
Hopwood sculp.

London, Published by Dr. Thornton Febr. 1. 1802.

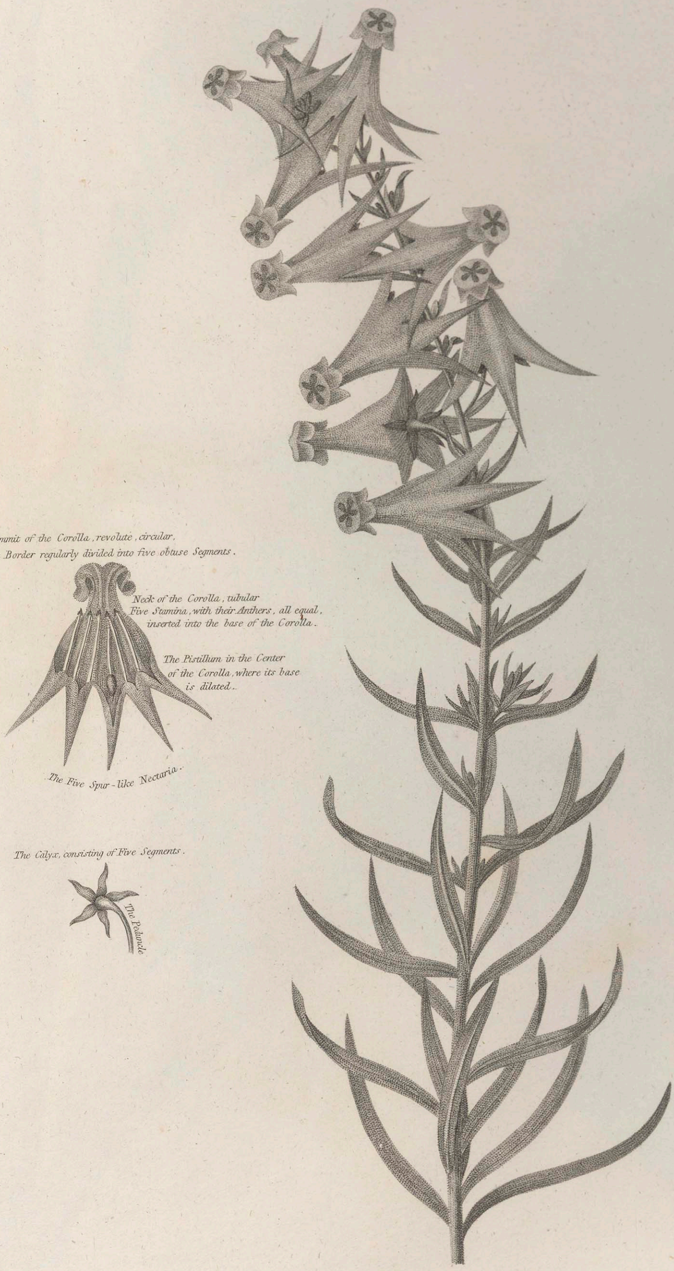
Male & Female Flowers on the same Plant.


Male Flower
Female
Calyx & Corolla the same in the Male & Female Flowers.
1. Calyx.
2. Corolla.
3. Stamina.
4. Pistillum.

The Imperial Jatropha.

Named in honor of the wise, magnanimous, and munificent Alexander, Emperor of Ruſsia.

Caldwall sculp.


Summit of the Corolla, revolute, circular,
The Border regularly divided into five obtuse Segments.
Neck of the Corolla, tubular
Five Stamina, with their Anthers, all equal, inserted into the base of the Corolla.
The Pistillum in the Center of the Corolla, where its base is dilated.
The Five Spur-like Nectaria.
The Calyx, consisting of Five Segments.
The Peduncle

Peloria or The Wonder.

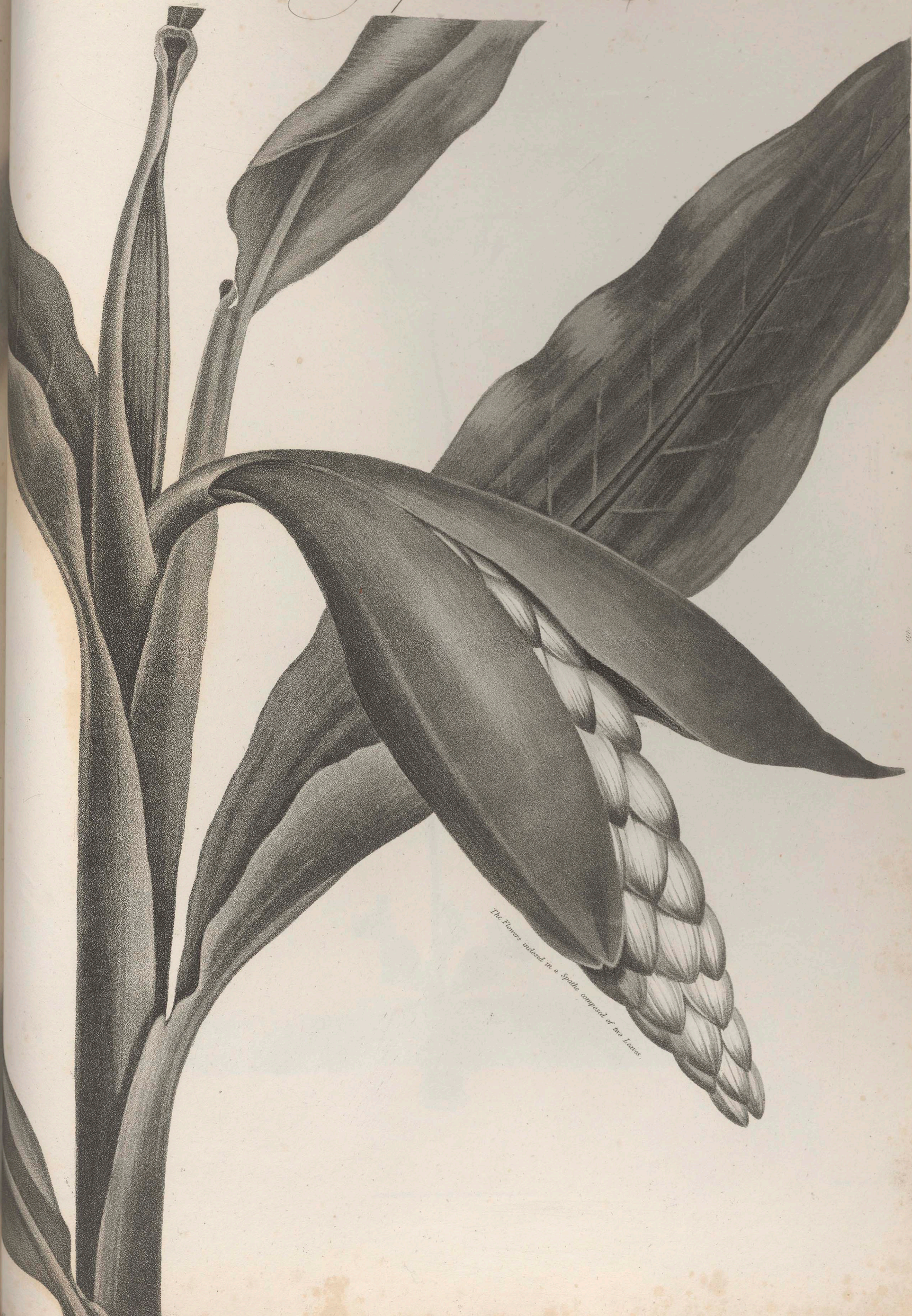
A Mule Plant so named by Linnæus on account of the Astonishment
that this Hybrid production created, when it was first shewn to Him.

Henderson del.

Warner sculp.

London, Published by Dr. Thornton March 1 1801.

First Stage of the Renealmia



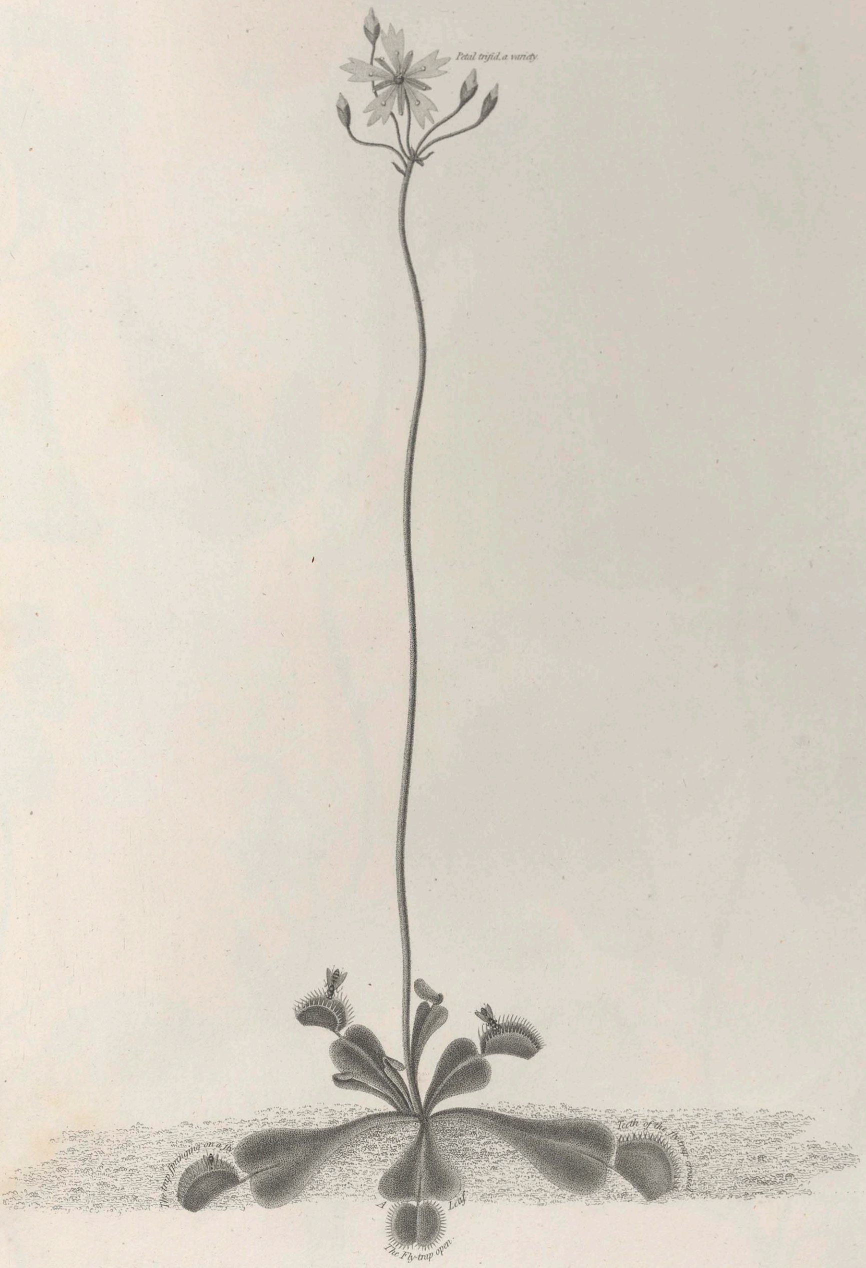
The Flowers inclosed in a Spathe composed of two Leaves.

London, Published Decr 1. 1802, by Dr Thornton.

Lewis sculp.

The Defence of Plants.

THE CATCH-FLY DIONÆA.

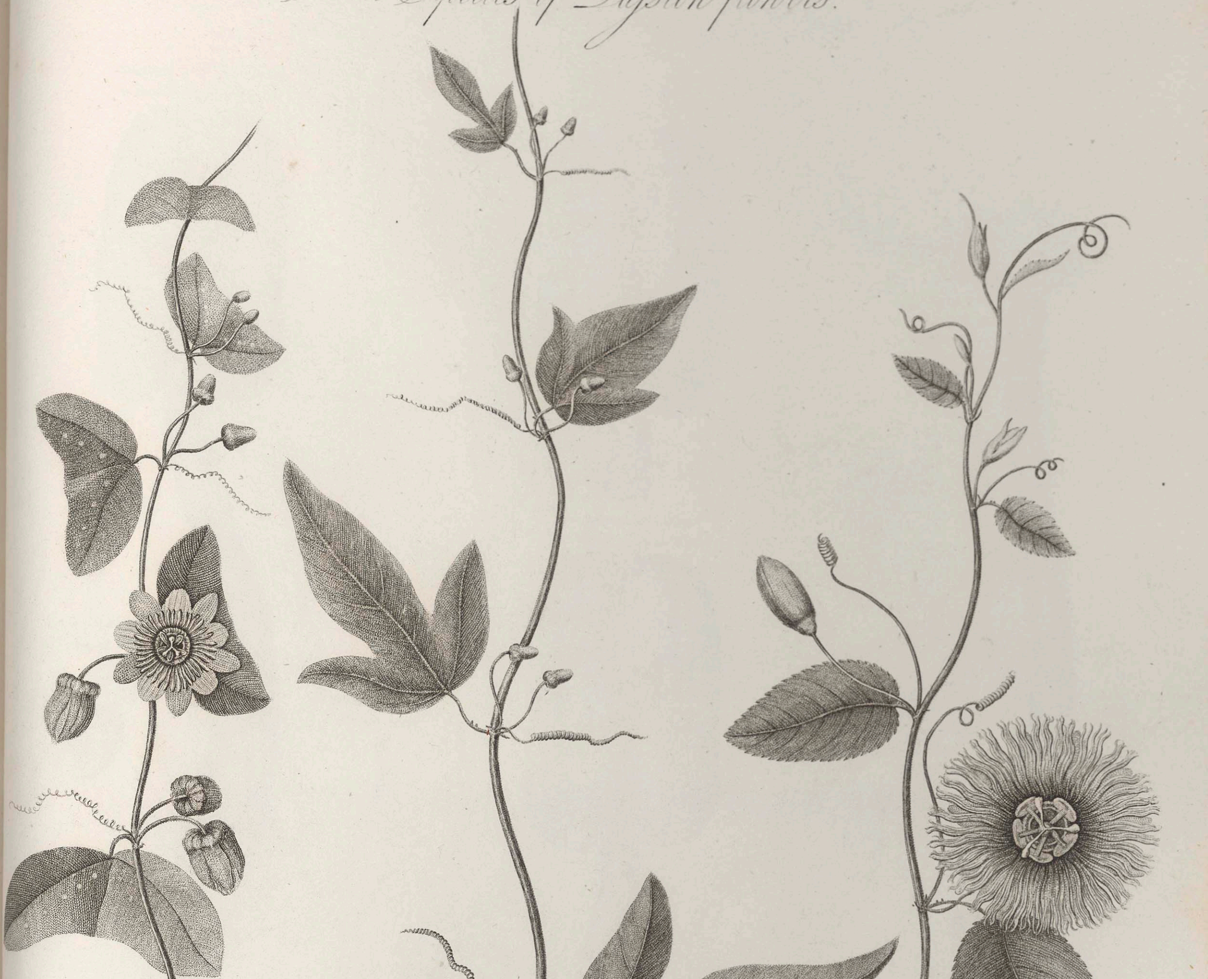

Petal trifid, a variety.
The trap ſpringing on a fly
A Leaf
The Fly-trap open.
Teeth of the fly-trap croſsed

Bishop pinx. ad viv.

London, Published by Dr. Thornton, August 1. 1802.

Warner sculp.

Three Species of Paſsion-flowers.



THE DOTTED,
Dots in the Leaves.

THE CORK,
Stem Cork.

THE SERRATED,
Edges of the Leaf toothed like a saw.

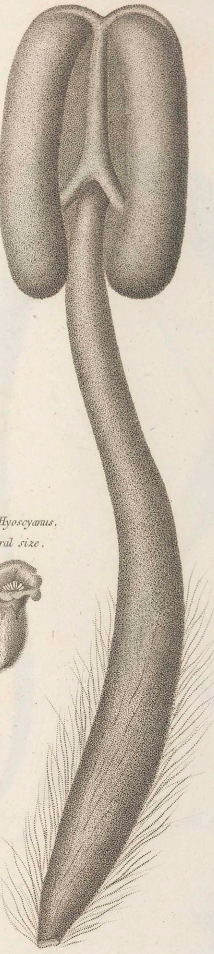
Bishop pinx^{t}

Warner sculp.

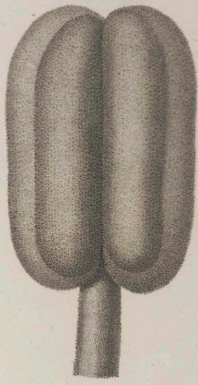
London Published by Dr Thornton June 1. 1803.

A Plate from Grew's Anatomy of Plants, published in 1682.

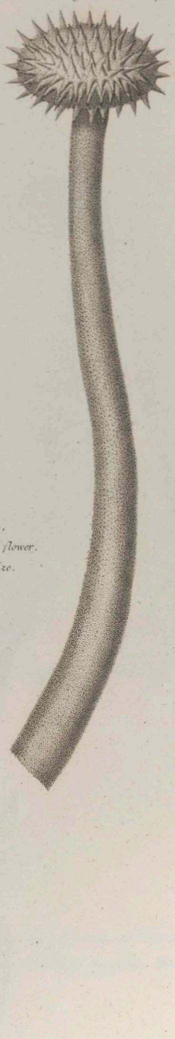
A back view of one of the Stamens,
as seen through the Microscope.



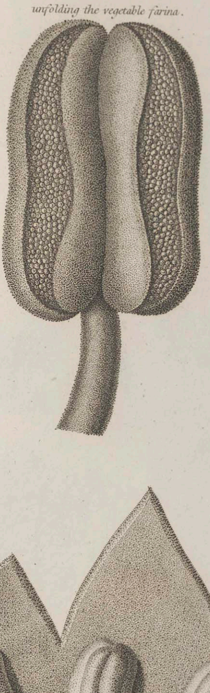
Do. a front view,
closed.



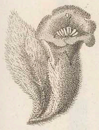
The Pistillum,
as seen through the Microscope.



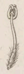
Its two compartments, open
unfolding the vegetable farina.



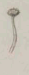
Flower of Hyoscyamus,
The natural size.

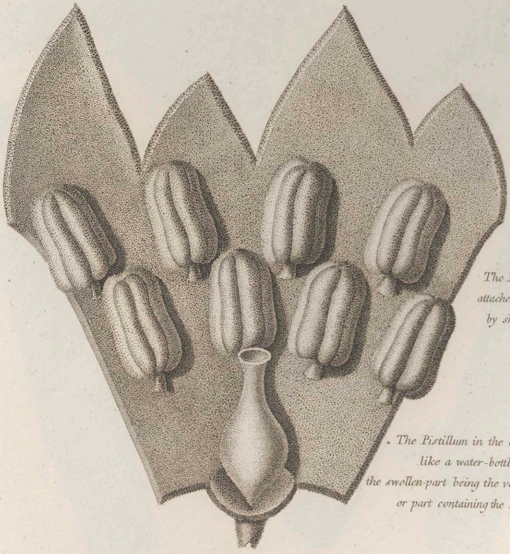


A Stamen,
or Male part of the flower.
The natural size.



The Pistillum,
or female part of the flower.
The natural size.

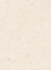




The Eight Stamina
attached to the Corolla,
by short filaments.

The Pistillum in the Center,
like a water-bottle,
the swollen-part being the vegetable womb,
or part containing the seeds.

Flower of Mesereon, in its young state.
The natural size.

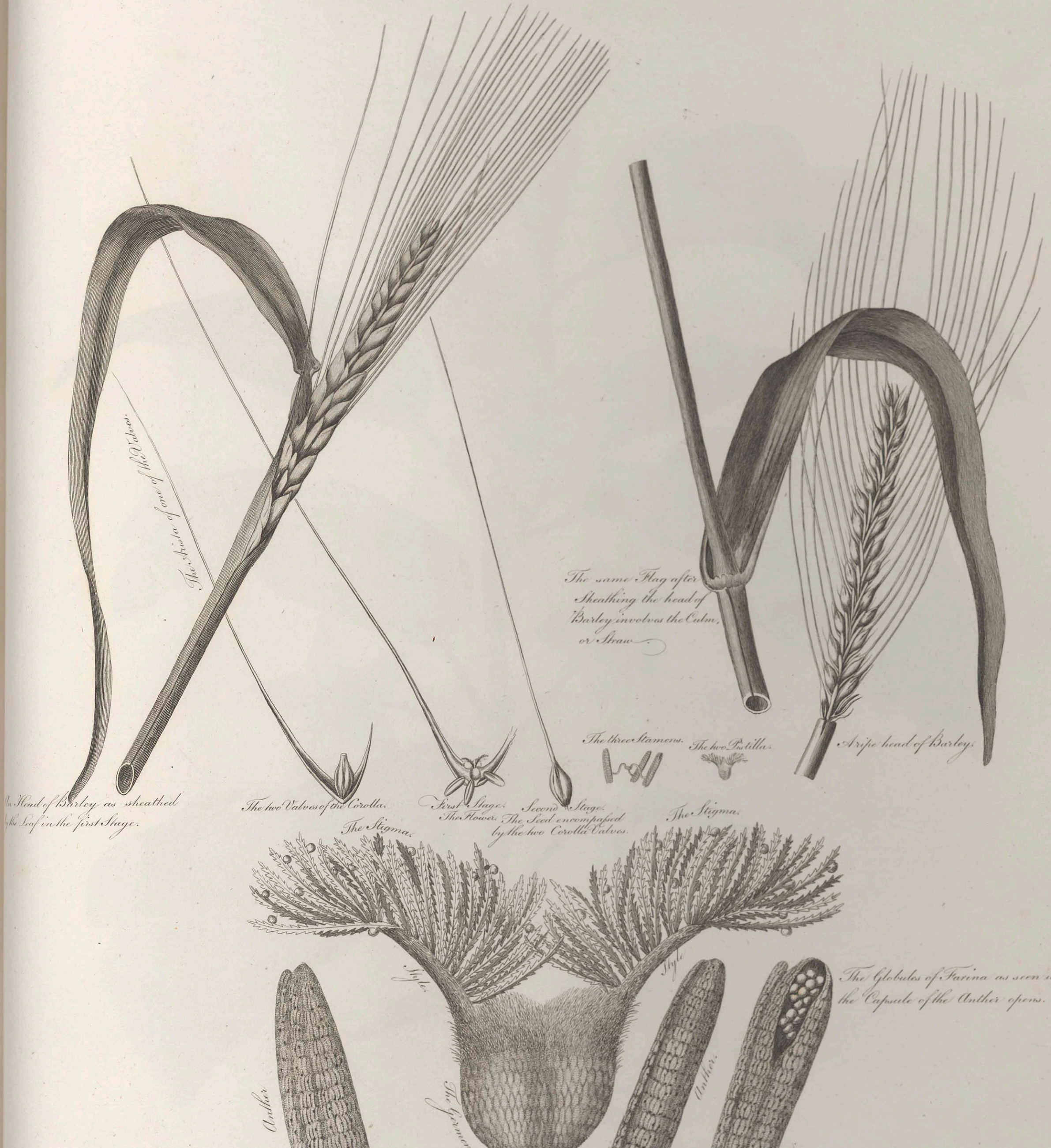


Grew del.

Warner sculp.

London, Published by Dr. Thornton, Feby. 1, 1803.

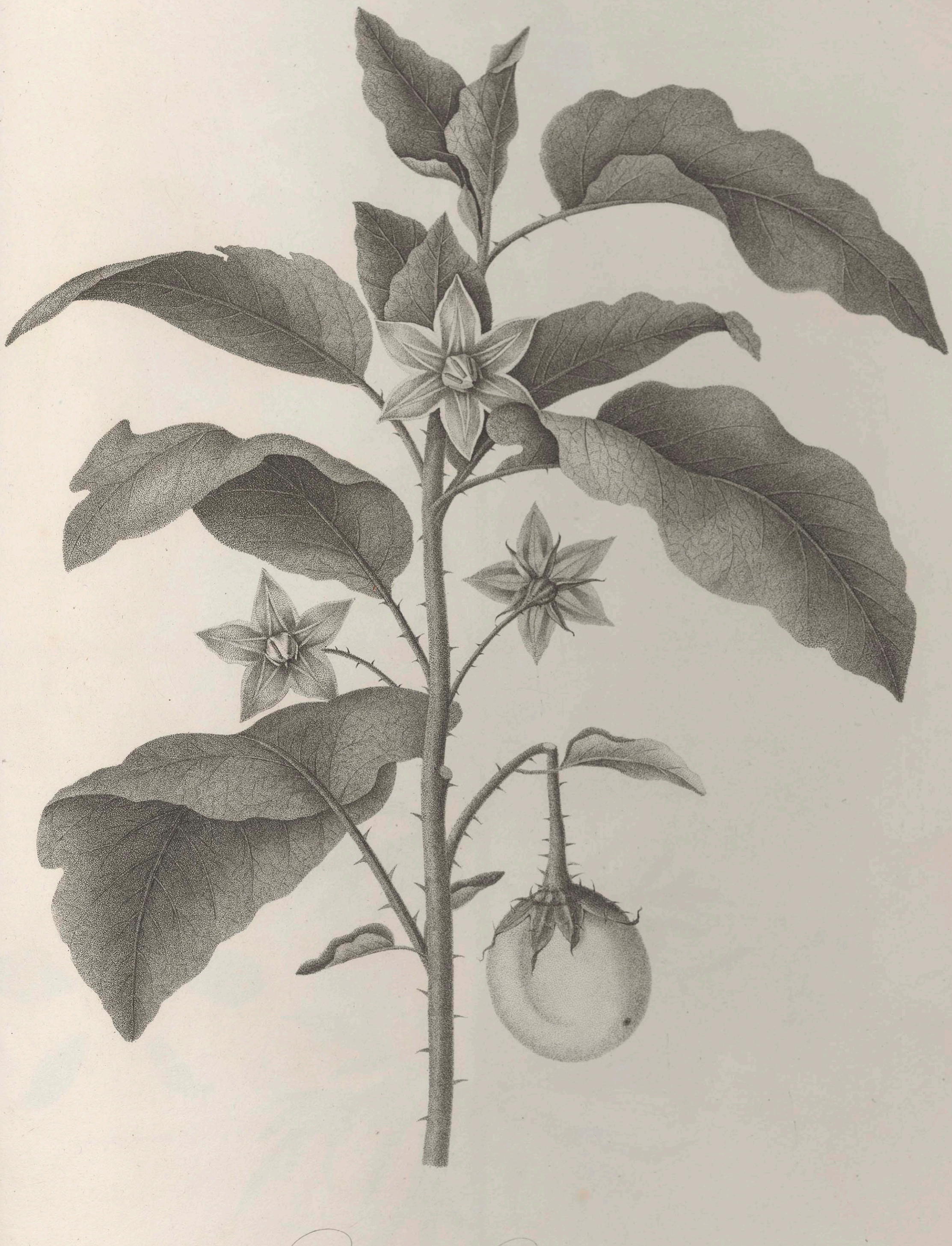
Barley.


The Arista of one of the Valves.
n Head of Barley as sheathed
y the Leaf in the first Stage.
The two Valves of the Corolla.
First Stage.
The Flower.
Second Stage.
The Seed encompassed
by the two Corolla Valves.
The same Flag after
Sheathing the head of
Barley involves the Culm,
or Straw.
The three Stamens.
The two Pistilla.
A ripe head of Barley.
The Stigma.
The Stigma.
Style.
Style.
The Globules of Farina as seen when
the Capsule of the Anther opens.
Anther.
The Germen.
Anther.
Anther.
Filament.
Filament.
Filament.

The three Stamens and two Pistilla greatly magnified.

ner del.

Mazel sculp.

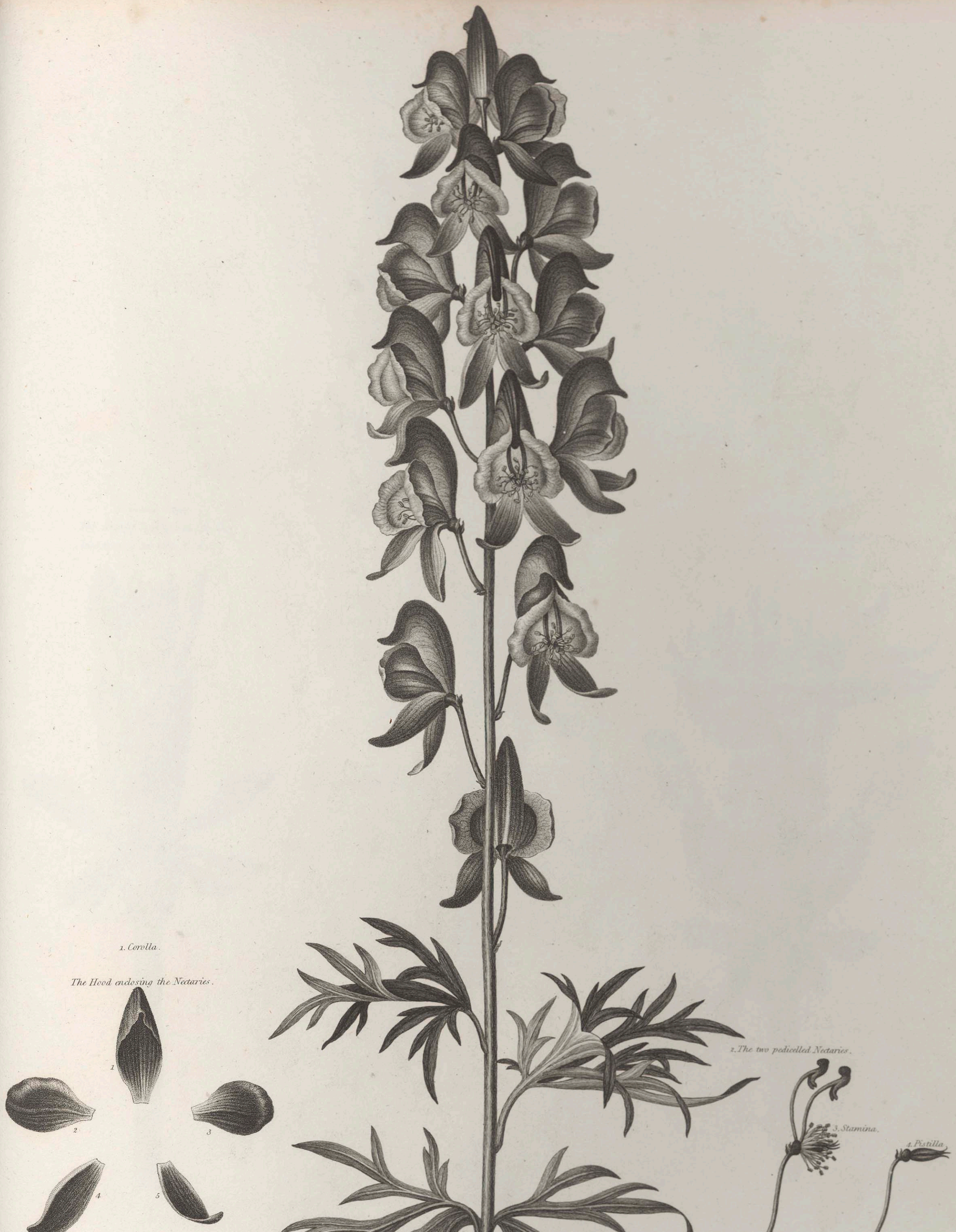


Henderson del.

The Egg Plant.

Warner sculp.

London, Published by Dr. Thornton, June 1, 1803.


1. Corolla.
The Hood enclosing the Nectaries.
1
2
3
4
5
1. 2. 3. 4. 5. The five Petals.
2. The two pedicelled Nectaries.
3. Stamina.
4. Pistilla.

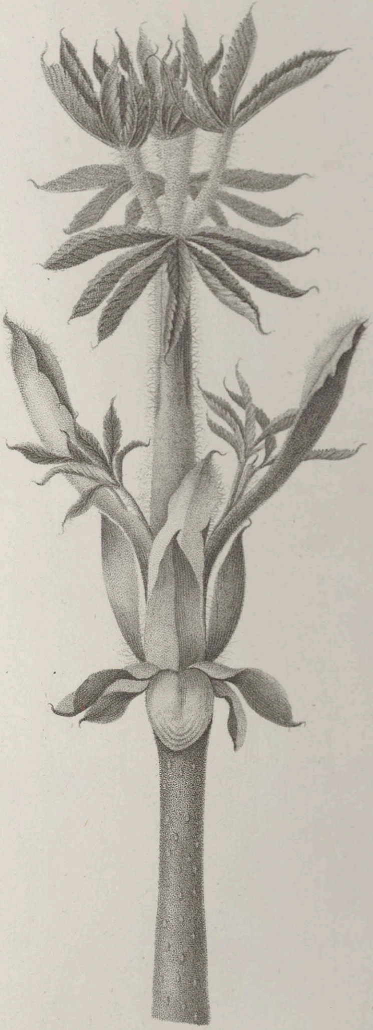
The Aconite or Monk's-Hood.

derson pinx.t

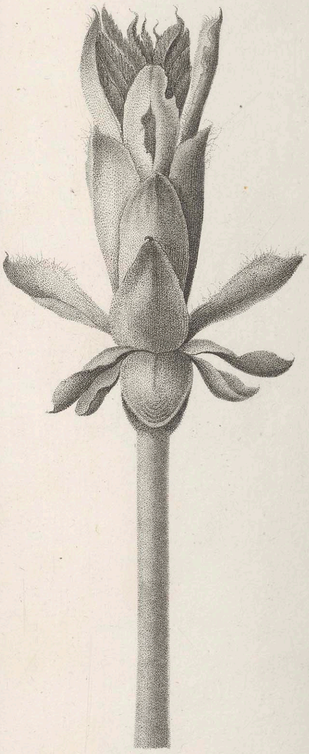
London, Published for Dr Thornton, Decr 1804.

Caldwall sculp.t

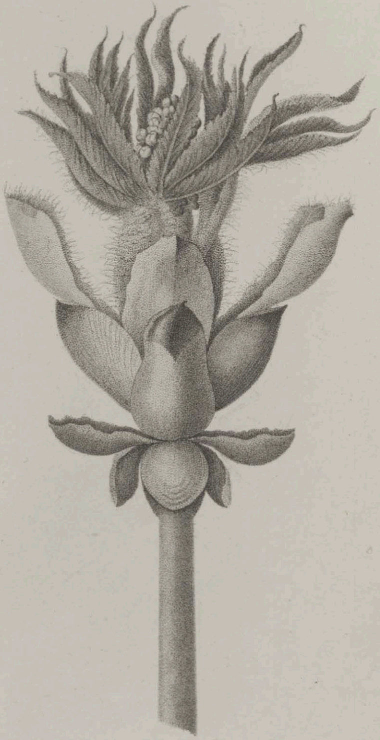
4. Fourth Stage.
These Parts more extended, and the lower tier of the digitated Leaves
taking on their natural shape and position round the Stalk.



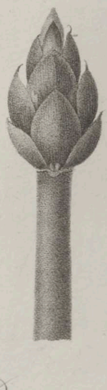
2. Second Stage.
The Stipulæ bending back for the
liberation of the other Parts.



3. Third Stage.
The infant Foliage & Flower covered
with the finest Pubescence, or Down.



1. First Stage.
Bud of the Horse-Chestnut,
The Stipulæ closed by a clammy Liquor.



The Protection of Leaves.

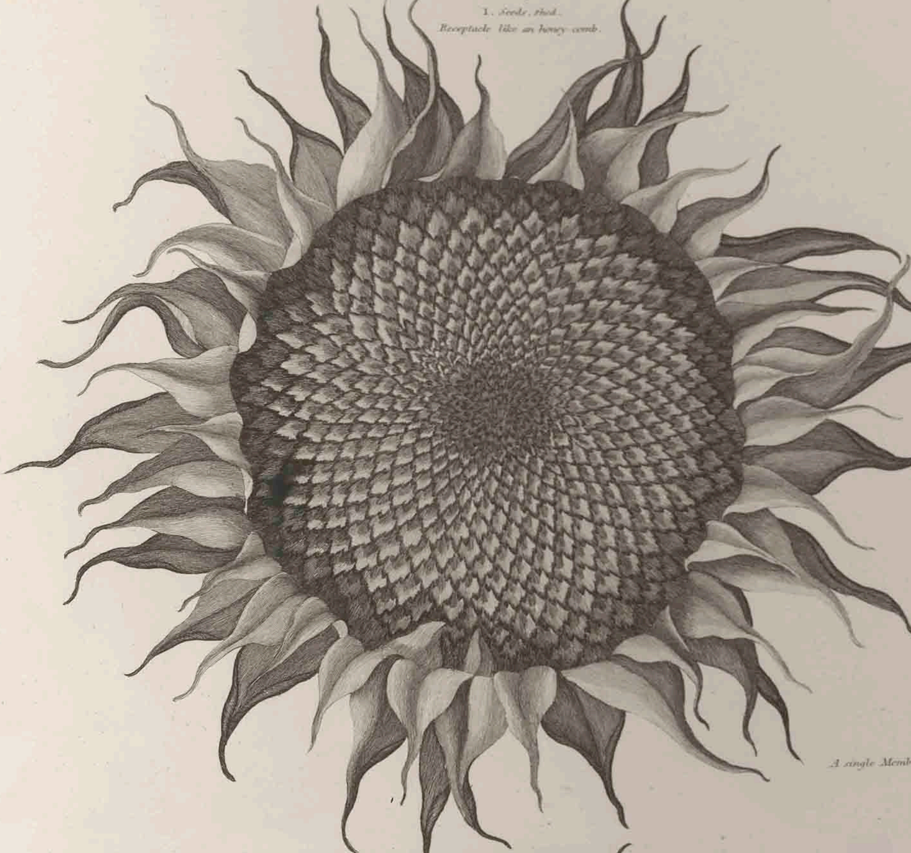
Henderson del.

Warner sculp.

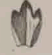
London, Published by Dr. Thornton, March 1, 1803.

Ripe Sunflower

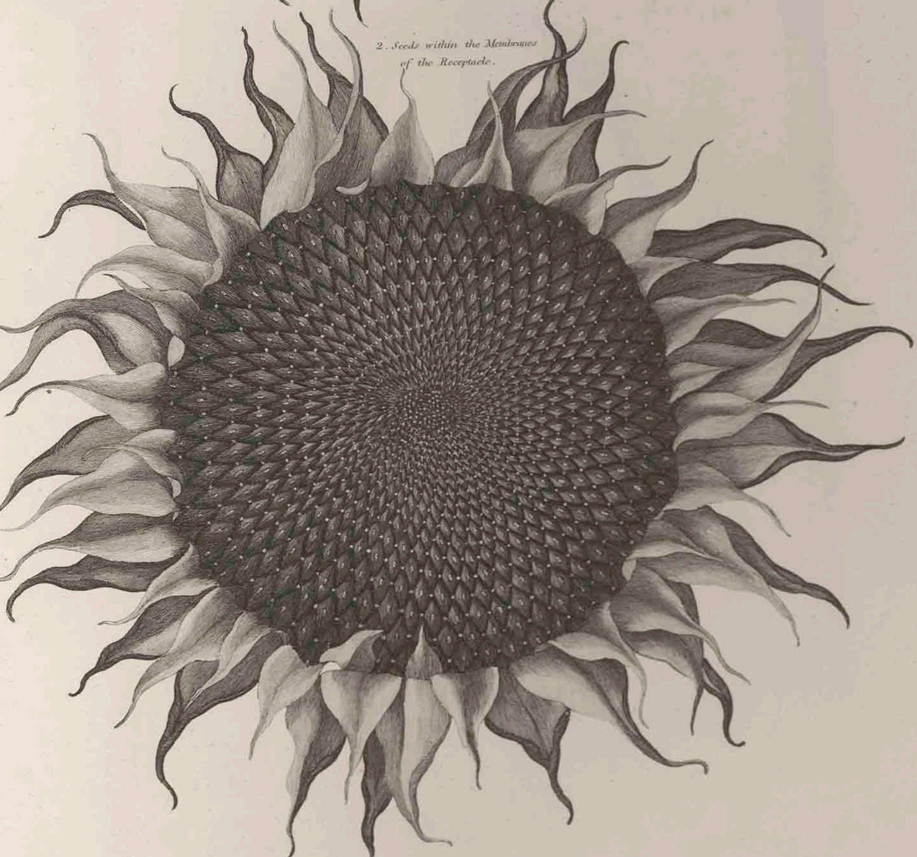
1. *Seeds, shed.*
Receptacle like an honey-comb.



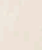
A single Membrane of the Receptacle.



2. *Seeds within the Membranes*
of the Receptacle.



A Seed.



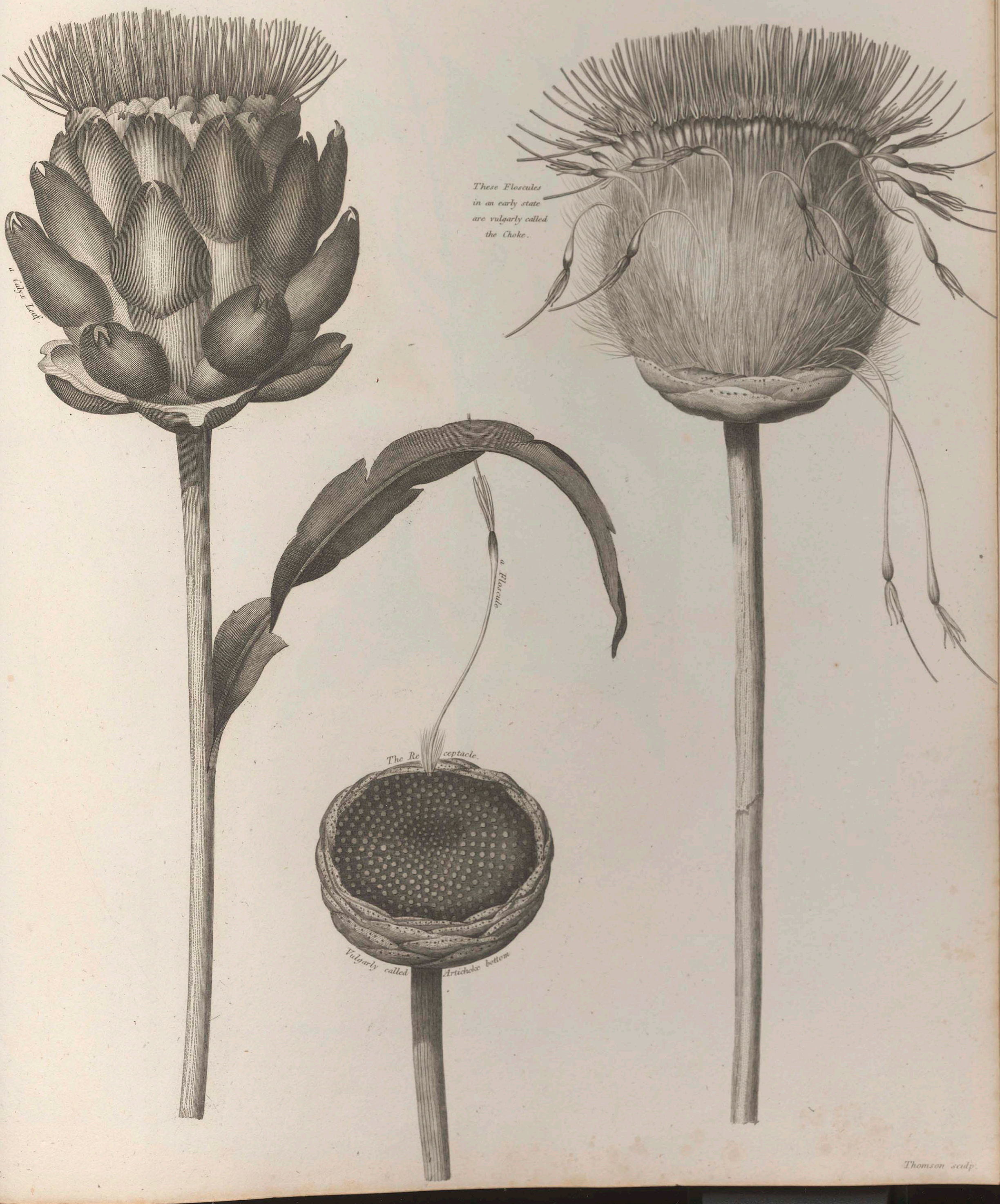
NB. Each seed is embraced by four Membranes.

Mazel sculp.

Artichoke in Flower

Calyx removed to shew the Floscules.

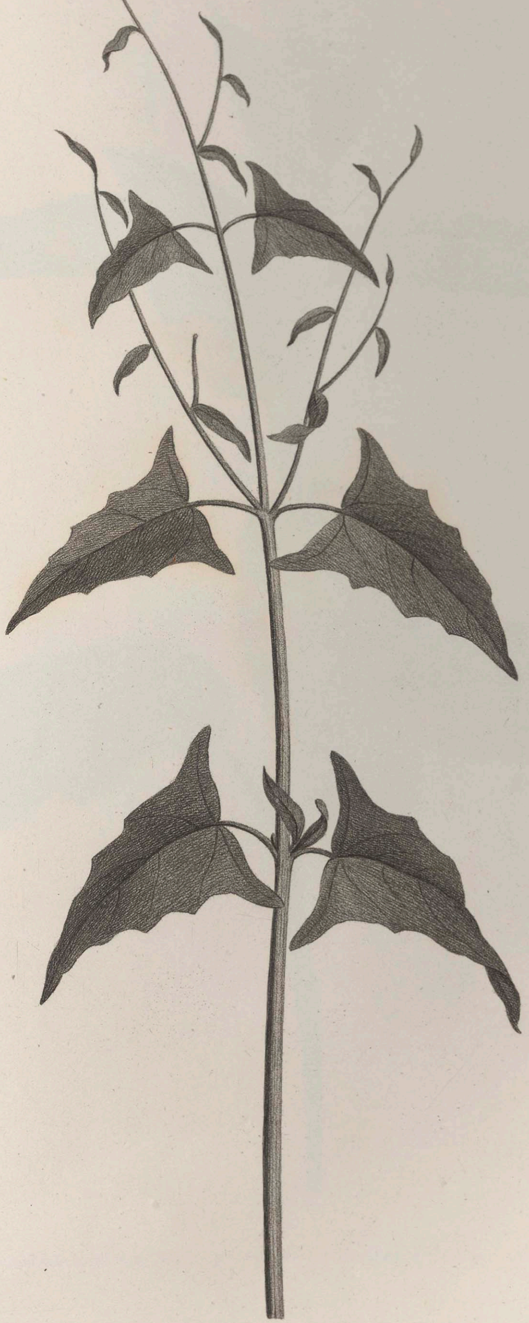
The Floscules protected by an Imbricated Calyx.


a Calyx Leaf.
These Floscules
in an early state
are vulgarly called
the Choke.
a Floscule
The Receptacle.
Vulgarly called Artichoke bottom

erson del.

Thomson sculp.

Leaves, triangular



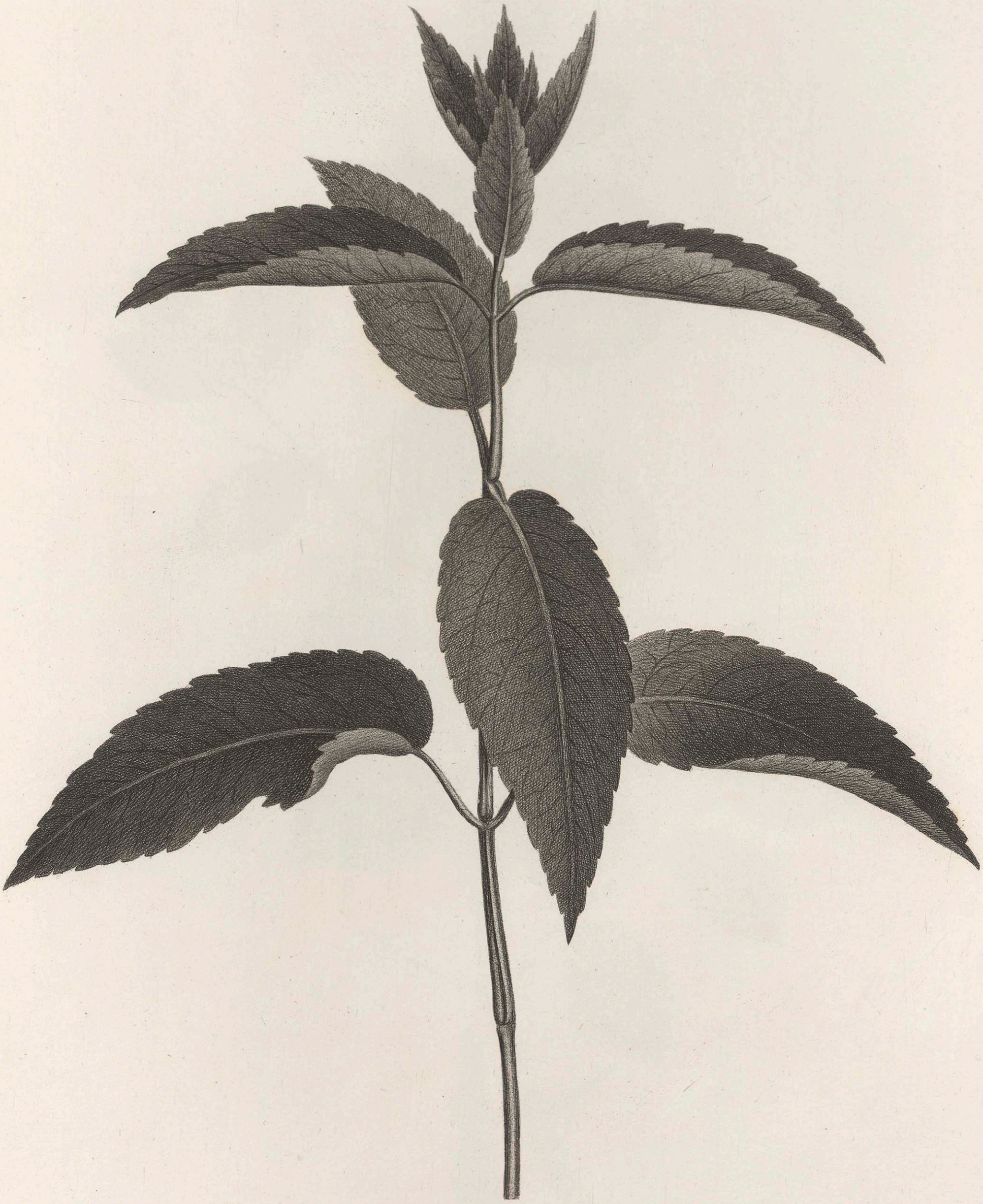
Example. Atriplex hastata. Broad-leaved wild Orache.

Henderson del.

London, Published by Dr. Thornton, Decr. 2. 1805.

Gaugain sculp.

Leaves opposite.



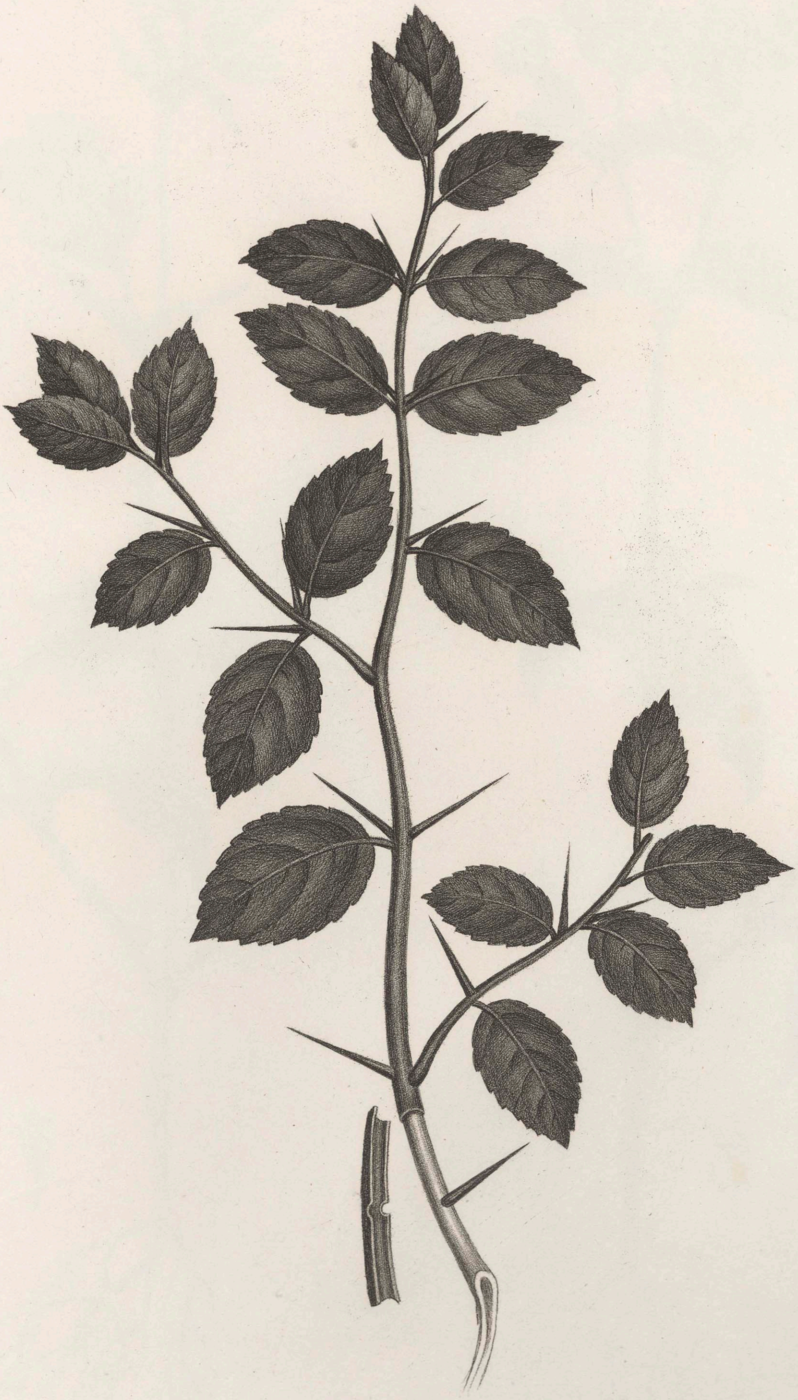
Example. Mercurialis perennis. Common Dogs Mercury.

Henderson del.

London, Published by Dr. Thornton, Decr. 1 1805.

Gaugain sculp.

Thorn, axillary.



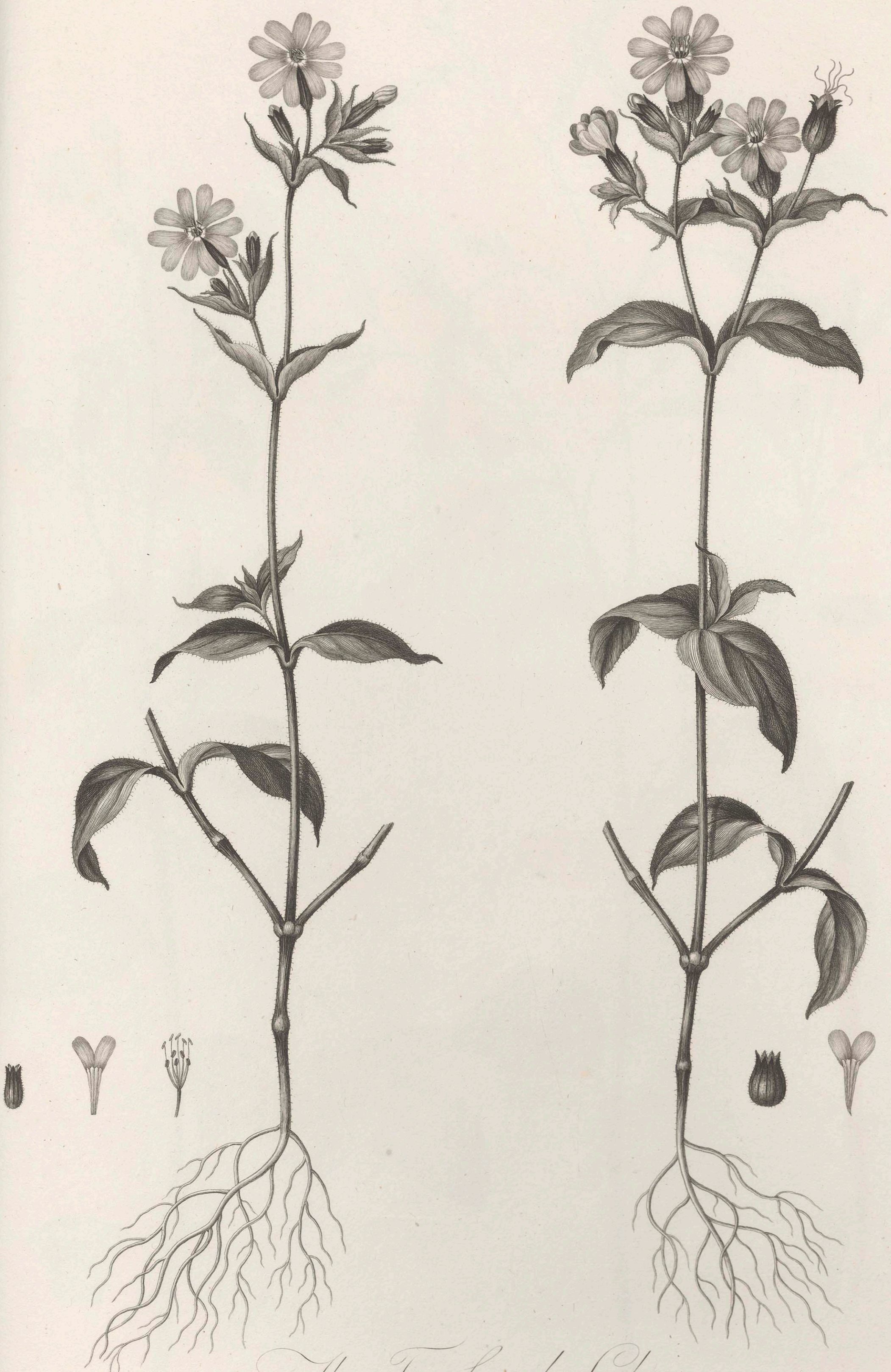
Example. Prunus spinosa. Black Thorn.

Henderson del.

Gaugain sculp.

London, Published by Dr. Thornton, Decr. 2 1805.

1. Male Plant. 2. Female Plant.

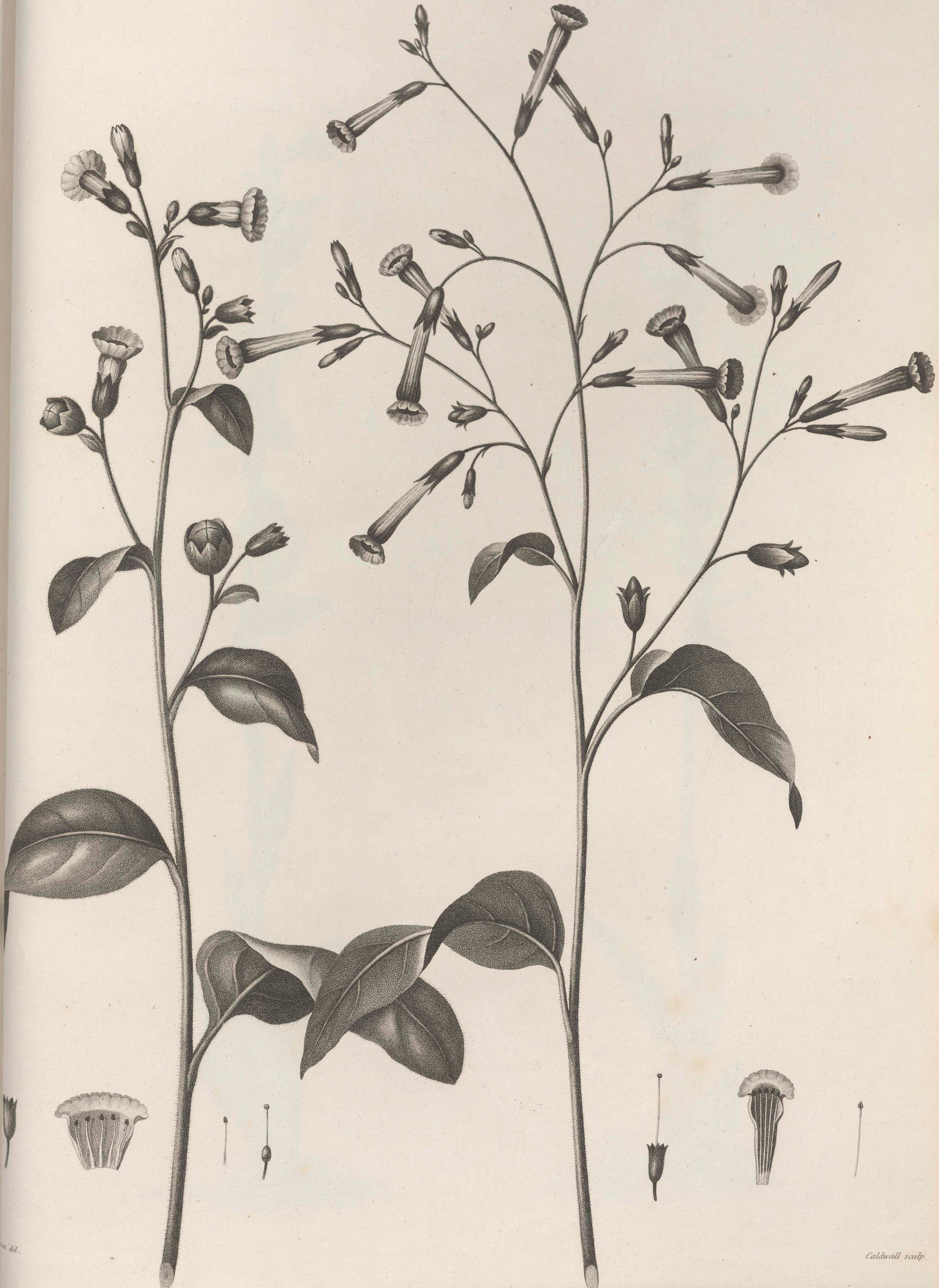


The Two-housed Lychnis.

nderson delt. Caldwall sculpt.

London. Published by Dr Thornton, Octr 1. 1805.

Nicotiana, Tobacco.



1. *Rustica*

2. *Paniculata*

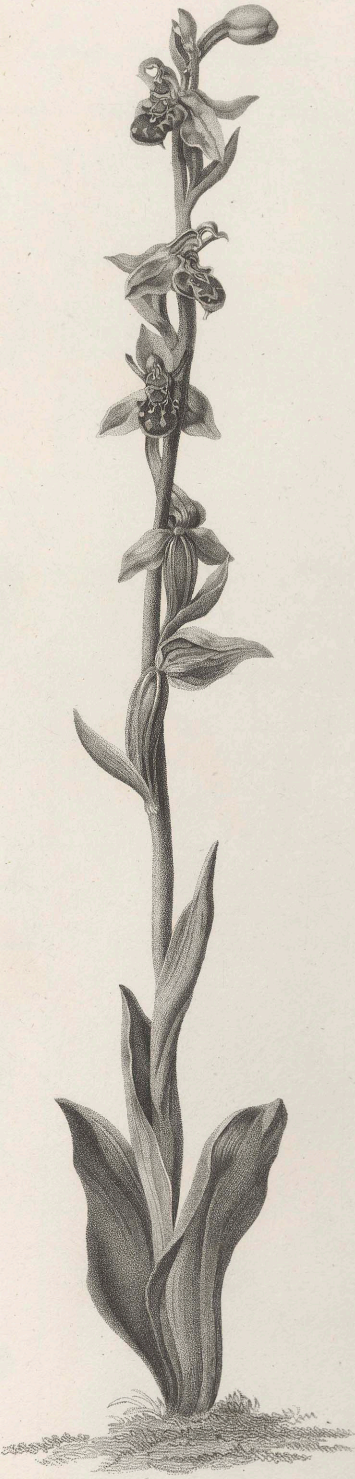
del.

Caldwall sculp.

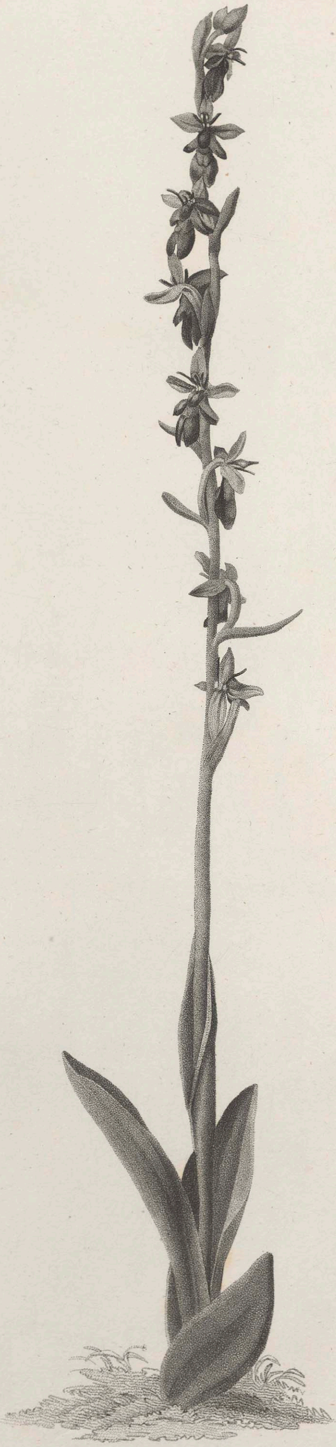
London, Published by Dr. Thornton, July 1

Plants whose Flowers resemble Insects.

THE BEE ORCHIS.



THE FLY ORCHIS.



Reinagle Senr. A. pinx

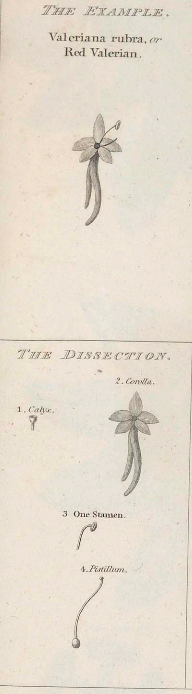
Hopwood sculp.

London, Published August 1. 1802, by Dr. Thornton, Hinde Street.

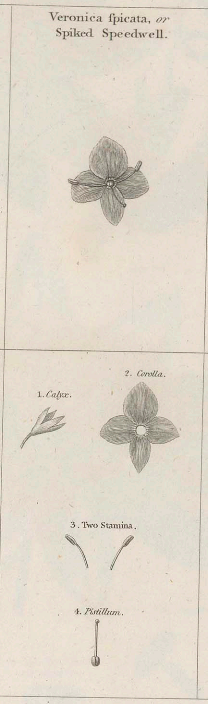
THE
Sexual System
OF
LINNÆUS.

Section 1st. CLASSES derived from the Consideration of the Number of Stamina only.

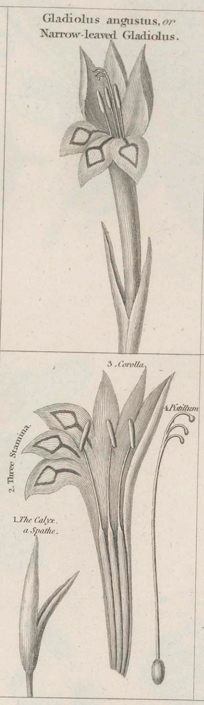
Claſs I. MONÁNDRIA.
1 Stamen.


THE EXAMPLE.
Valeriana rubra, or
Red Valerian.
THE DISSECTION.
1. Calyx.
2. Corolla.
3 One Stamen.
4. Pistillum.

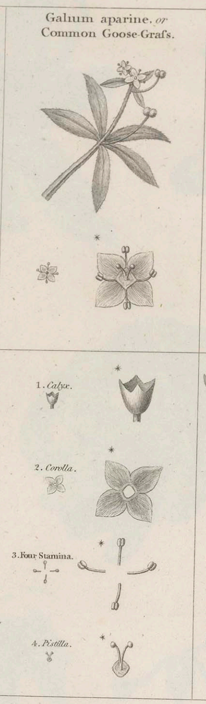
Claſs II. DIÁNDRIA.
2 Stamina.


Veronica ſpicata, or
Spiked Speedwell.
1. Calyx.
2. Corolla.
3. Two Stamina.
4. Pistillum.

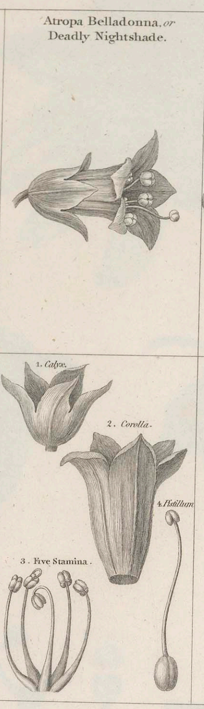
Claſs III. TRIÁNDRIA.
3 Stamina.


Gladiolus angustus, or
Narrow-leaved Gladiolus.
1. The Calyx. a Spathe.
2. Three Stamina.
3. Corolla.
4. Pistillum

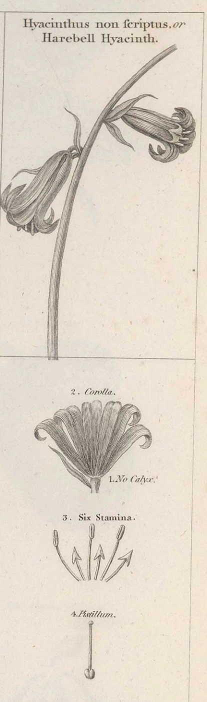
Claſs IV. TETÁNDRIA.
4 Stamina.


Galium aparine, or
Common Goose-Graſs.
*
1. Calyx.
2. Corolla.
3. Four Stamina.
4. Pistilla.

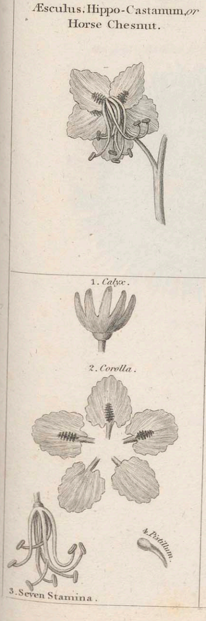
Claſs V. PENTÁNDRIA.
5 Stamina.


Atropa Belladonna, or
Deadly Nightshade.
1. Calyx.
2. Corolla.
3. Five Stamina.
4. Pistillum

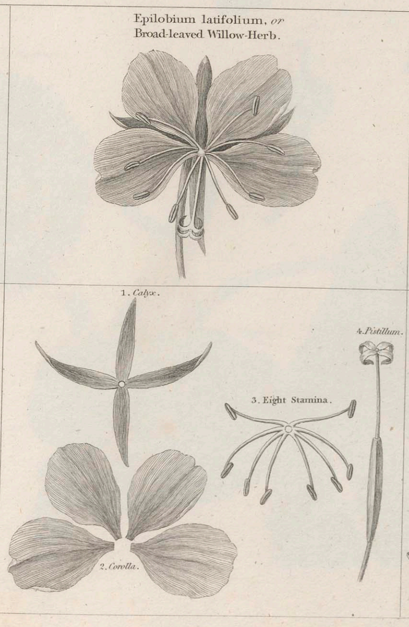
Claſs VI. HEXÁNDRIA.
6 Stamina.


Hyacinthus non ſcriptus, or
Harebell Hyacinth.
2. Corolla.
1. No Calyx.
3. Six Stamina.
4. Pistillum.

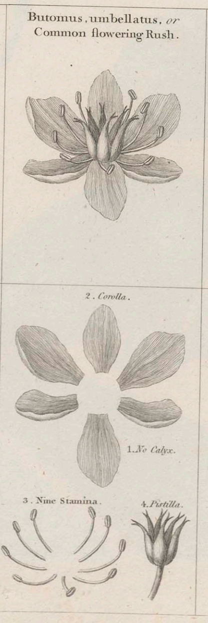
Claſs VII. HEPTÁNDRIA.
7 Stamina.


Æsculus, Hippo-Castanum, or
Horse Chesnut.
1. Calyx.
2. Corolla.
3. Seven Stamina.
4. Pistillum.

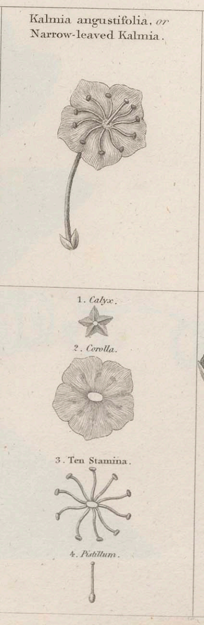
Claſs VIII. OCTÁNDRIA.
8 Stamina.


Epilobium latifolium, or
Broad-leaved Willow-Herb.
1. Calyx.
2. Corolla.
3. Eight Stamina.
4. Pistillum.

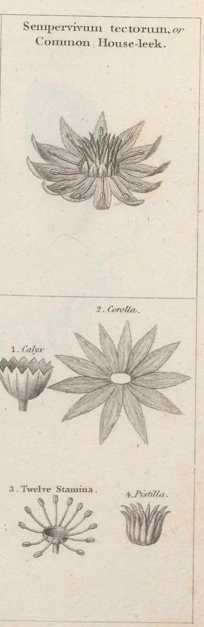
Claſs IX. ENNEÁNDRIA.
9 Stamina.


Butomus, umbellatus, or
Common flowering Rush.
2. Corolla.
1. No Calyx.
3. Nine Stamina.
4. Pistilla.

Claſs X. DECÁNDRIA.
10 Stamina.


Kalmia angustifolia, or
Narrow-leaved Kalmia.
1. Calyx.
2. Corolla.
3. Ten Stamina.
4. Pistillum.

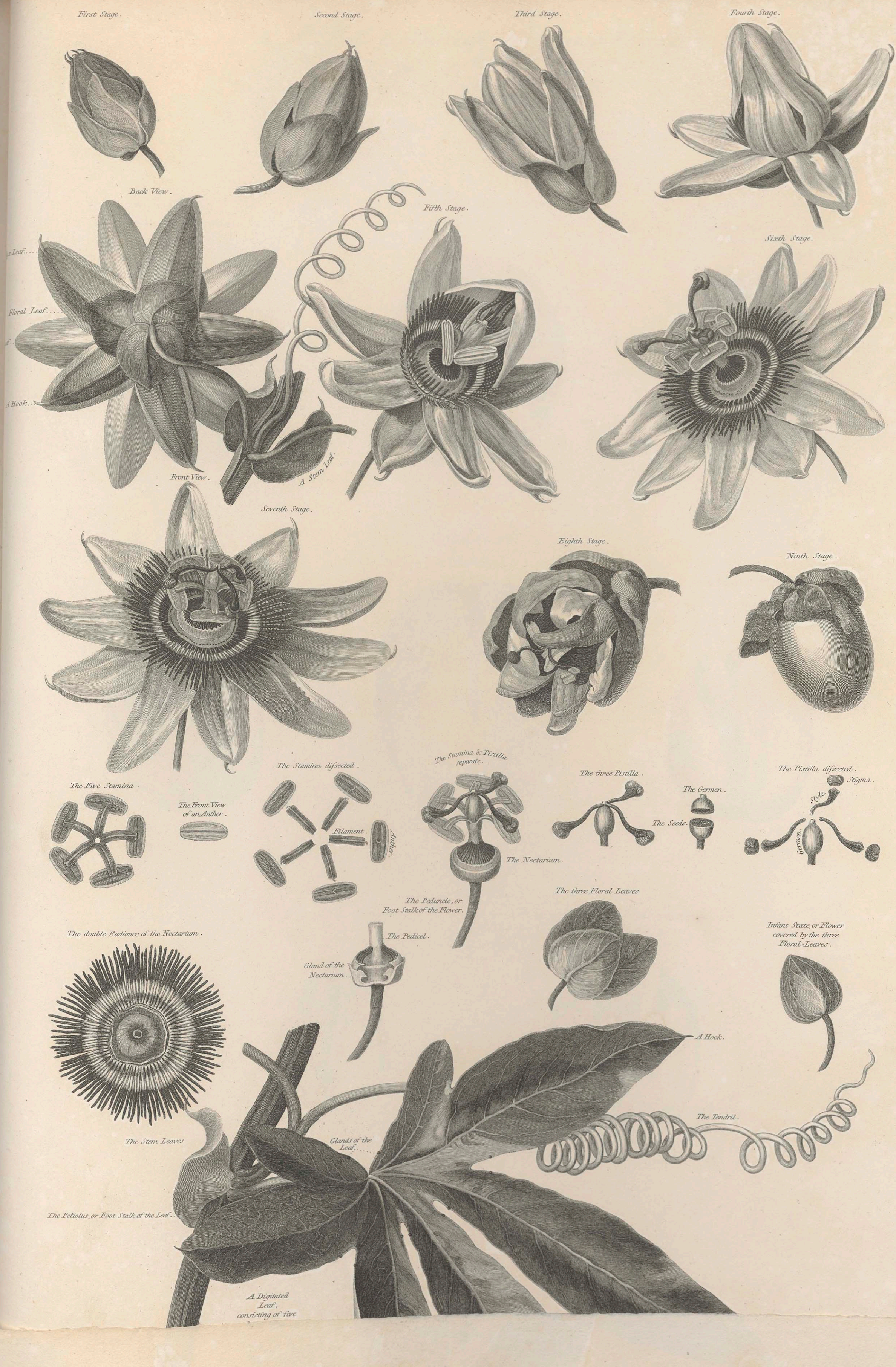
Claſs XI. DODECÁNDRIA.
12 Stamina.


Sempervivum tectorum, or
Common House-leek.
1. Calyx
2. Corolla.
3. Twelve Stamina.
4. Pistilla.

London, Published by Dr. Thornton, Febʳ. 1. 1802.

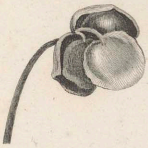
Henderson delin.

ANATOMY of the BLUE PASSION FLOWER.

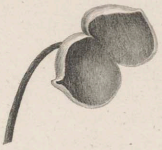

First Stage.
Second Stage.
Third Stage.
Fourth Stage.
Back View.
Leaf.
Floral Leaf.
A Hook.
Front View.
A Stem Leaf.
Fifth Stage.
Sixth Stage.
Seventh Stage.
Eighth Stage.
Ninth Stage.
The Five Stamina.
The Front View of an Anther.
The Stamina diſsected.
Filament.
Anther.
The Stamina & Pistilla separate.
The Nectarium.
The Peduncle, or Foot Stalk of the Flower.
The three Pistilla.
The Germen.
The Seeds.
The Pistilla diſsected.
Stigma.
Style.
Germen.
The three Floral Leaves
The double Radiance of the Nectarium.
The Pedicel.
Gland of the Nectarium.
Infant State, or Flower covered by the three Floral-Leaves.
A Hook.
The Tendril.
The Stem Leaves
Glands of the Leaf.
The Petiolus, or Foot Stalk of the Leaf.
A Digitated Leaf, consisting of five

THE MALE FLOWER.

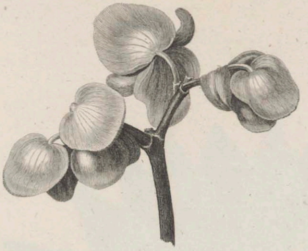
1. *Male flowers protected by a membranous Sheath.*



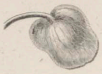
2. *This Sheath exposed.*



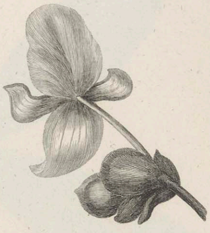
3. *Male flowers in Clustres before expansion.*



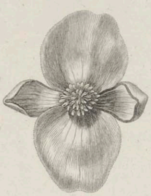
4. *The First State, or the petals closed.*



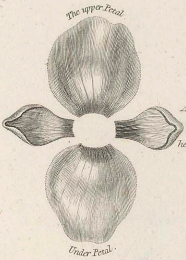
5. *Back View of a male flower.*



6. *Front View of a male flower.*

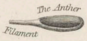


7. *The Four Petals of the male flower separate.*


The upper Petal
A side Petal inversely heart shaped.
Under Petal.

8. *The numerous Stamina in the center of the male flower.*

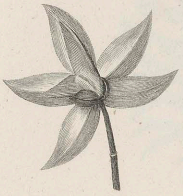
9. *A Stamen magnified.*


The Anther
Filament

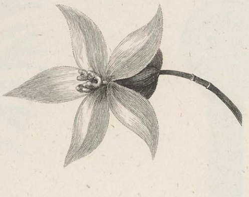
10. *The fructifying Pollen.*

THE FEMALE FLOWER.

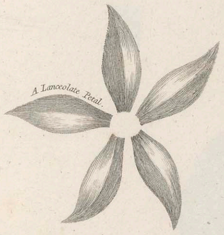
11. *Back View of a female flower.*



12. *Front View of a female flower.*



13. *The Five Petals of the female flower separate.*


A Lanceolate Petal.

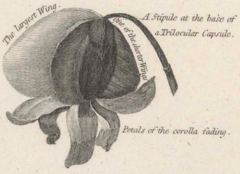
14. *A Tricuspid Pistillum in the center of the female flower.*

The Three styles coalesced at their base.

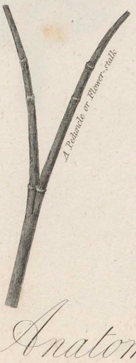
15. *One of these separate.*

Stigma, two headed, forked.
Style very short.

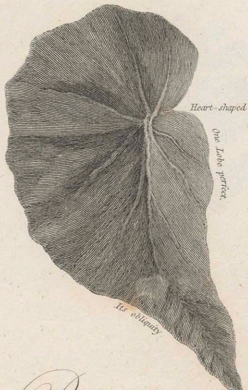
16. *A Three-winged Seed-Veſsel.*


The Largest Wing.
One of the shorter Wings
A Stipule at the baſe of a Trilocular Capsule.
Petals of the corolla fading.

17. *The Stalk supporting the Female Flowers, dichotomous or forked.*


A Peduncle or Flower-stalk.

18. *A Leaf.*


Heart-shaped.
One Lobe perfect.
Its obliquity.

Reinagle pinx.

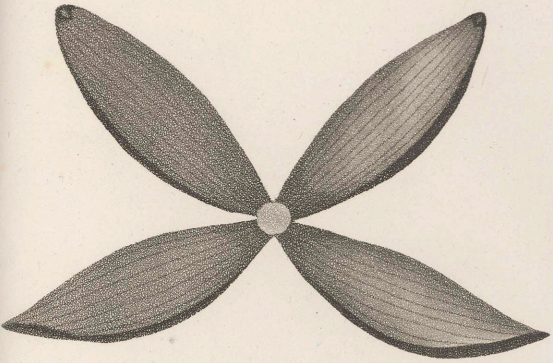
Anatomy of the Begonia.

London, Published by Dr. Thornton March 1, 1801.

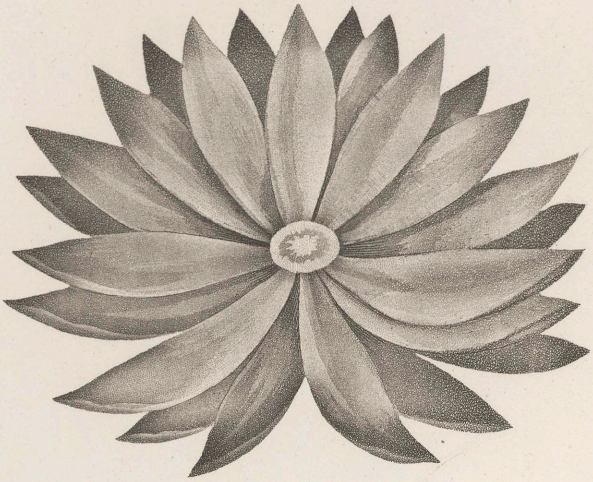
Caldwall sculp.

Anatomy of the Blue Egyptian Water-Lily.

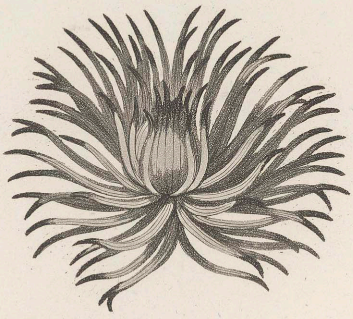
I. Calyx.



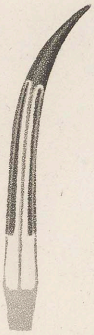
II. Corolla.



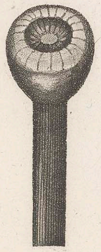
III. Stamina.



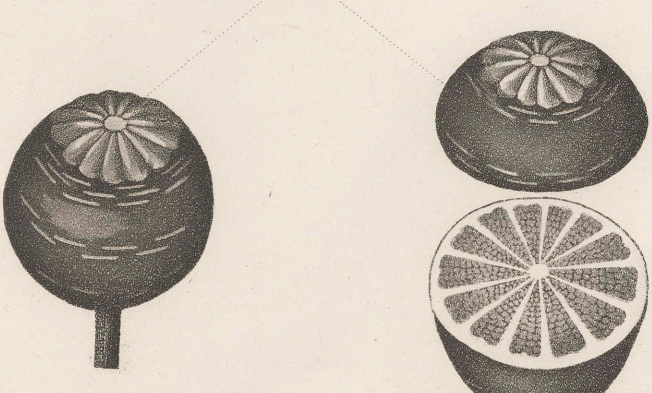
A Stamen Magnified.



IV. Pistillum.



V. Pericarp.

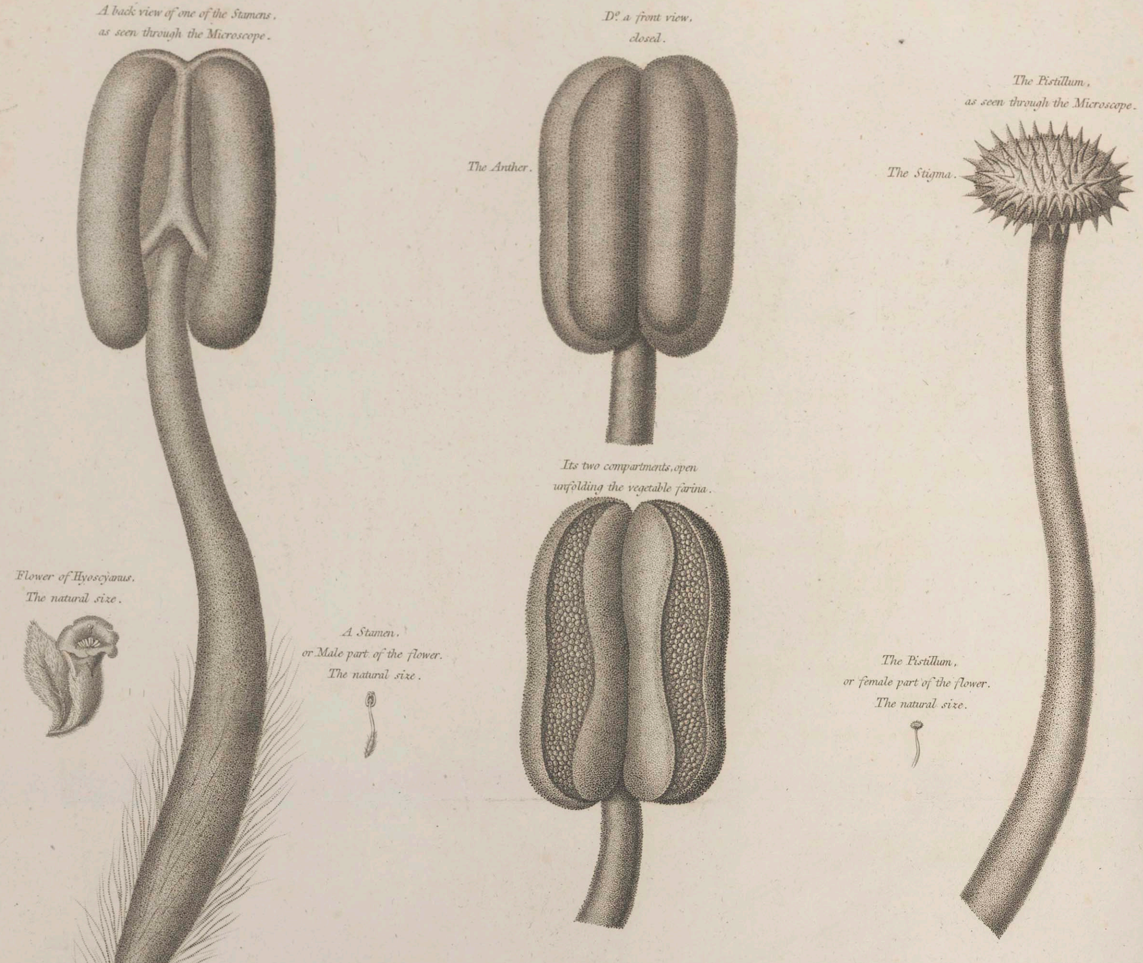


Henderson pinx.

London, Published by Dr. Thornton, Feb. 1. 1805.

Elmes sculp.

A Plate from Grew's Anatomy of Plants, published in 1682.

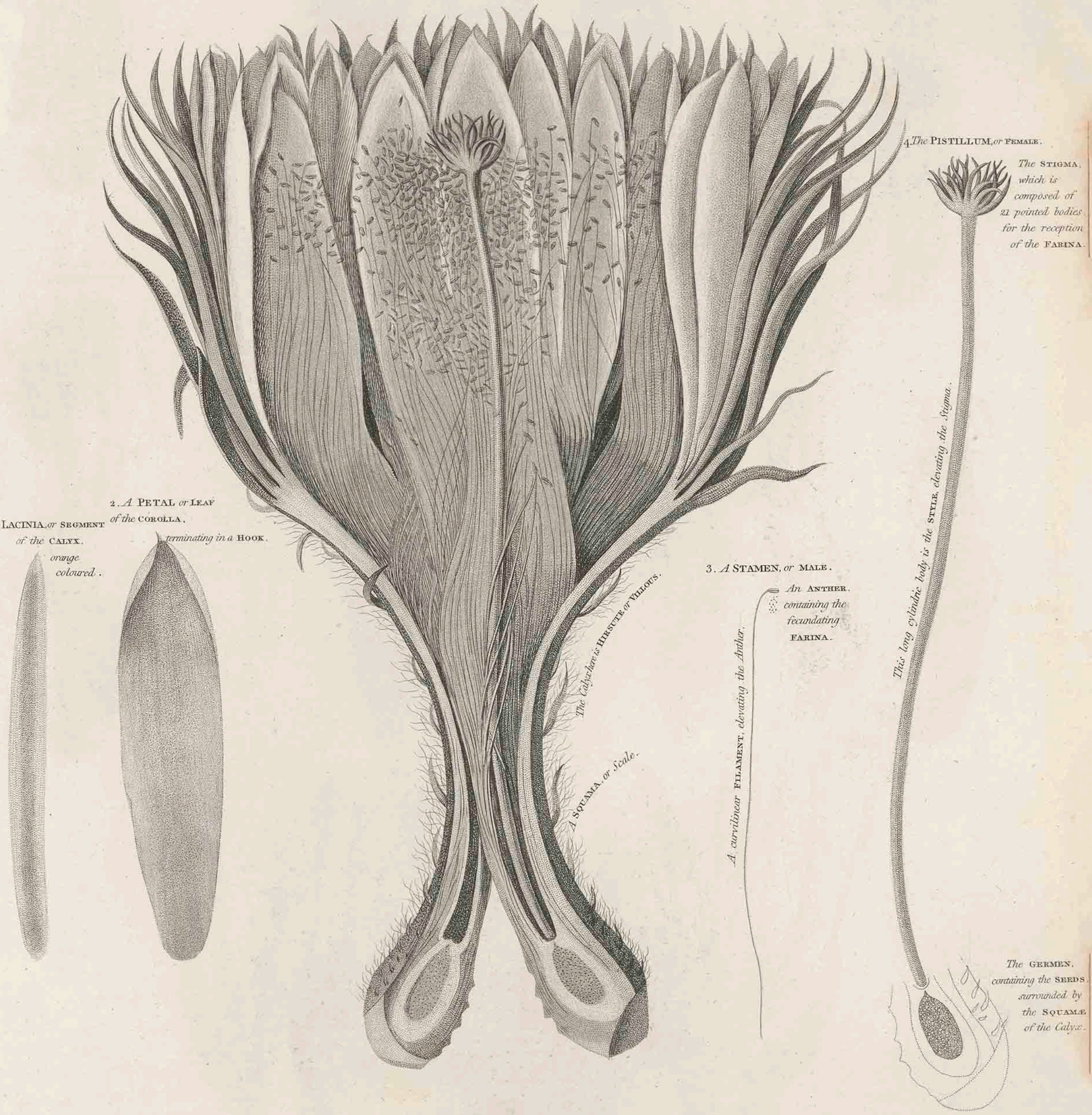

A back view of one of the Stamens, as seen through the Microscope.
Dº. a front view, closed.
The Anther.
The Pistillum, as seen through the Microscope.
The Stigma.
Its two compartments, open unfolding the vegetable farina.
Flower of Hyoscyamus. The natural size.
A Stamen, or Male part of the flower. The natural size.
The Pistillum, or female part of the flower. The natural size.
The Eight Stamina attached to the Corolla, by short filaments.
Flower of Mesereon, in its young state. The natural size.
The Pistillum in the Center, like a water-bottle, the swollen-part being the vegetable womb, or part containing the seeds.

Grew del.

Warner sculp.

London, Published by Dr. Thornton, Feby. 1, 1803.

Anatomy of the Night-blowing Cereus:
or
Cactus Grandiflora of Linnæus.

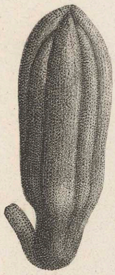

1. *A* LACINIA, *or* SEGMENT *of the* CALYX.
orange coloured.
2. *A* PETAL *or* LEAF *of the* COROLLA, *terminating in a* HOOK.
The Calyx here is HIRSUTE *or* VILLOUS.
A SQUAMA, *or Scale.*
3. *A* STAMEN, *or* MALE.
An ANTHER, *containing the fecundating* FARINA.
A curvilinear FILAMENT, *elevating the Anther.*
4. *The* PISTILLUM, *or* FEMALE.
The STIGMA, *which is composed of 21 pointed bodies for the reception of the* FARINA.
This long cylindric body is the STYLE, *elevating the Stigma.*
The GERMEN, *containing the* SEEDS *surrounded by the* SQUAMÆ *of the Calyx.*

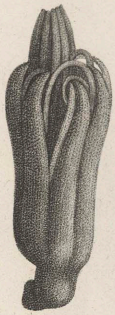
Reinagle pinx.

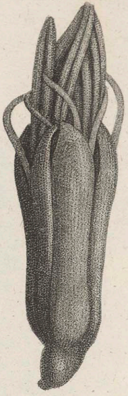
Warner sculp.

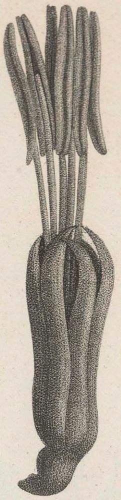
London, Published by Dr. Thornton May 1 1801.

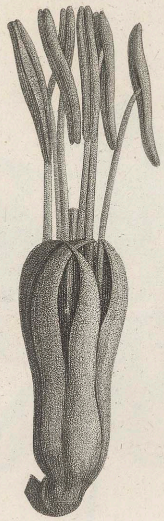
Anatomy of the Agave, or American Aloe

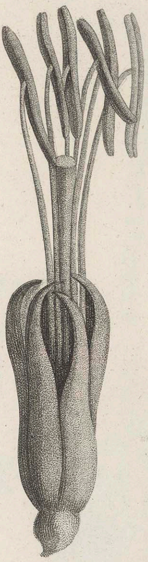

1. *First Stage,*
Petals closed.

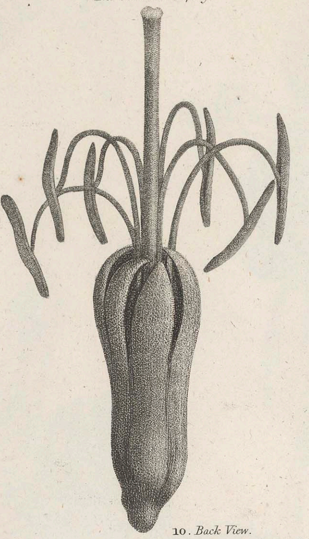

2. *Second Stage,*
Anthers peeping.
Filaments curled downwards.

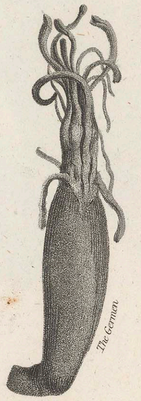

3. *Third Stage,*
Filaments taking their position.

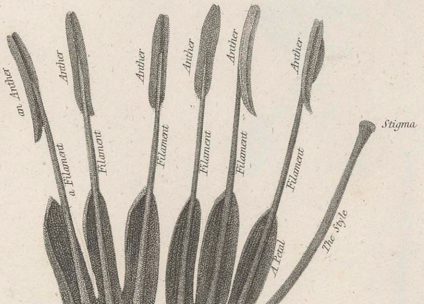

4. *Fourth Stage,*
Filaments erect.

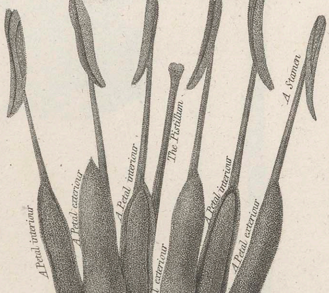

5. *Fifth Stage,*
Pistillum peeping.

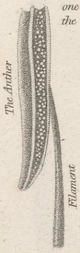

6. *Sixth Stage,*
Pistillum nearly the height of the Stamina
Flower in Perfection.

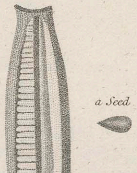

7. *Seventh Stage,*
The impregnated Pistillum elongated
The Stamina drooping.

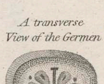

8. *Eighth Stage,*
All except the Germen
decayed.

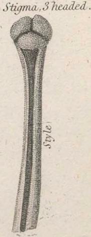

9. *Front View.*
To shew the six Stamina &c.
an Anther
Anther
Anther
Anther
Anther
Anther
a Filament
Filament
Filament
Filament
Filament
Filament
Stigma
A Petal
The Style
The Peduncle
a Germen, or Seed-veſsel


10. *Back View.*
Shewing the 3 interiour & 3 exteriour Petals of the Corolla.
A Petal interiour
A Petal exteriour
A Petal interiour
A Petal exteriour
The Pistillum
A Petal interiour
A Petal exteriour
A Stamen
The Peduncle
Germen


12. *The Anther, and Filaments*
enlarged.
one side discloses
the farina.
The Anther
Filament


11. *The Germen magnified*
To shew the disposition of the Seeds
which are removed on one side.


A transverse
View of the Germen.

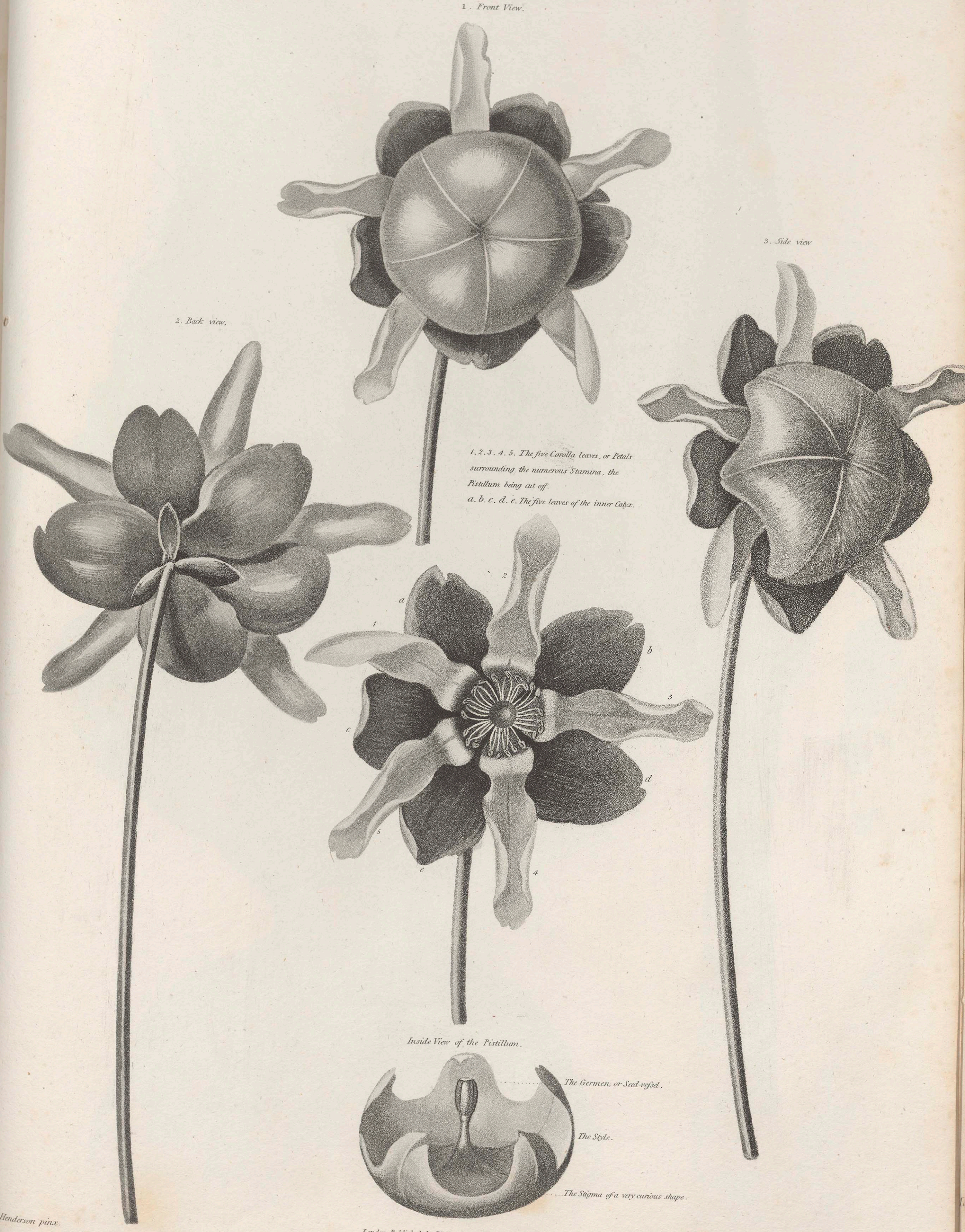

13. *Pistillum enlarged*
The Stigma 3 headed.

Reinagle and Pether del.

Warner sculp.

London, Published by Dr. Thornton, May 1.1801.

Anatomy of the Sarracenia
or
PITCHER PLANT.



1. *Front View.*

2. *Back view.*

3. *Side view*

1.2.3.4.5. The five Corolla leaves, or Petals surrounding the numerous Stamina, the Pistillum being cut off.

a.b.c.d.e. The five leaves of the inner Calyx.

Inside View of the Pistillum.

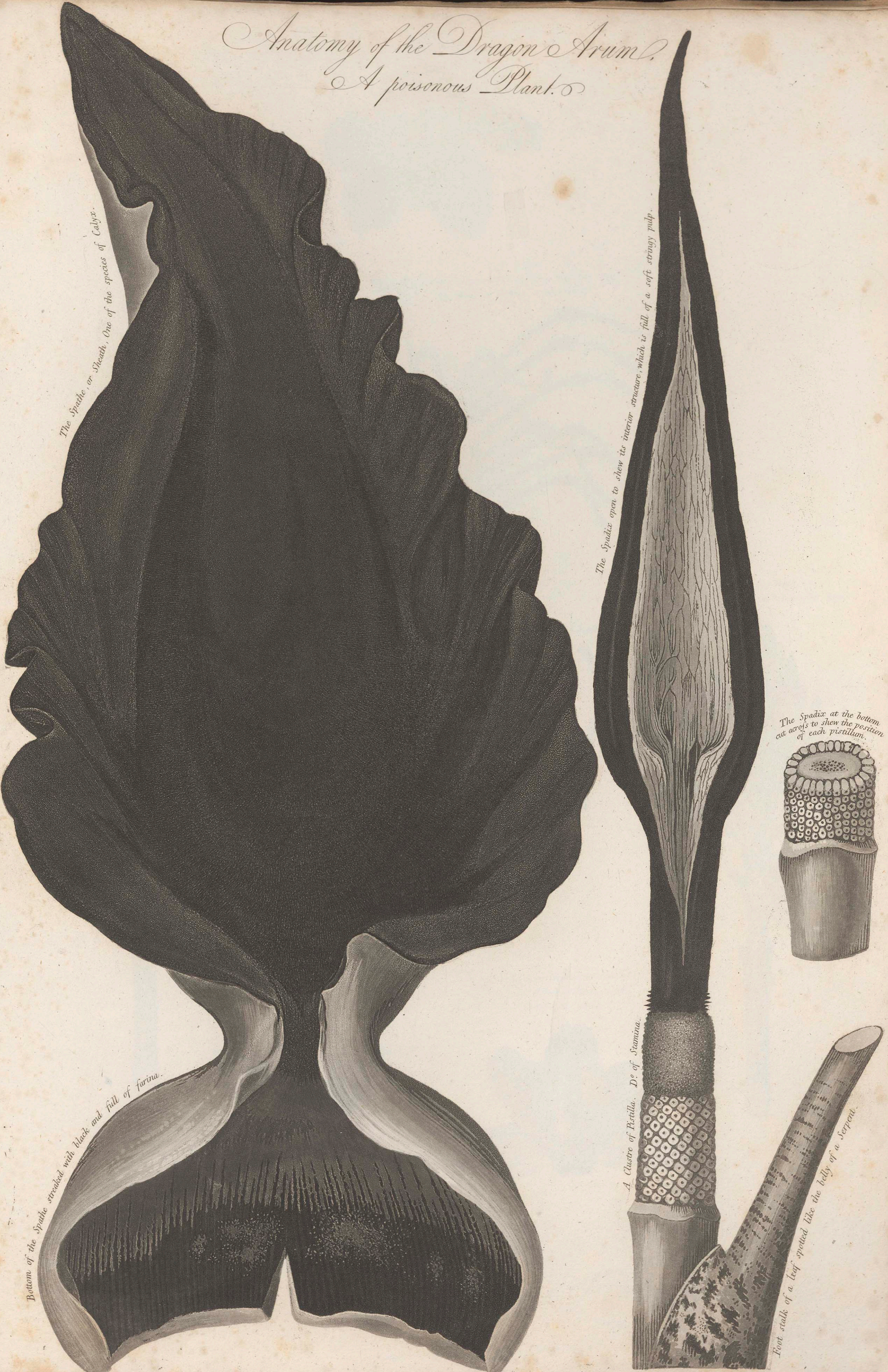
a
2
1
b
3
c
d
5
e
4
The Germen, or Seed-vessel.
The Style.
The Stigma of a very curious shape.

Henderson pinx.

London, Published by Dr. Thornton, August 1. 1802.

Lewis sculp.

Anatomy of the Dragon Arum.
A poisonous Plant.



The Spathe, or Sheath, One of the species of Calyx.

Bottom of the Spathe streaked with black and full of farina.

The Spadix open to shew its interior structure, which is full of a soft stringy pulp.

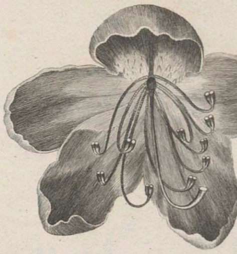
The Spadix at the bottom cut acroſs to shew the position of each pistillum.

A Clustre of Pistilla. D^o. of Stamina.

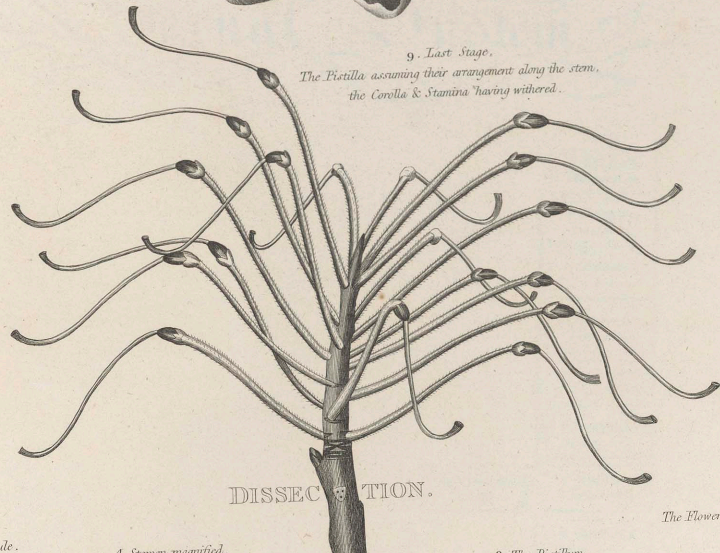
Foot stalk of a leaf spotted like the belly of a Serpent.

Henderson pinx.

3. *Third Stage,*
An expanded flower as seen in front.

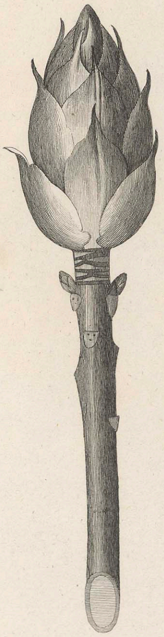


9. *Last Stage,*
The Pistilla assuming their arrangement along the stem, the Corolla & Stamina having withered.

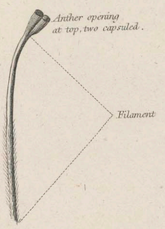


DISSECTION.

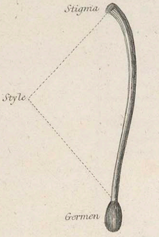
1. *The First Stage,*
Flower enclosed by the Stipule.



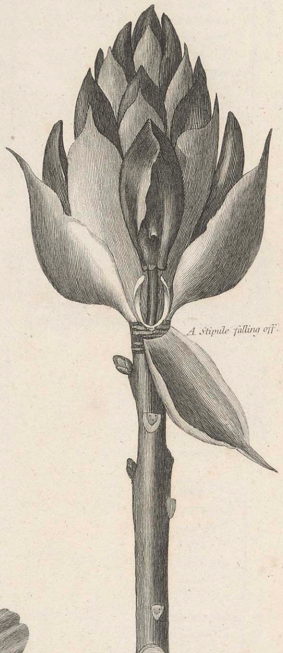
7. *A Stamen magnified.*


Anther opening at top, two capsuled.
Filament

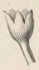
8. *The Pistillum.*


Stigma
Style
Germen

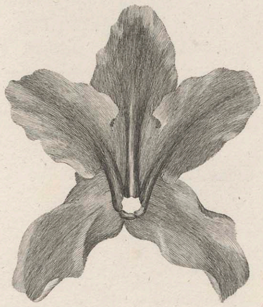
2. *The Second Stage,*
The Flowers bursting from between the Stipules.


A Stipule falling off.

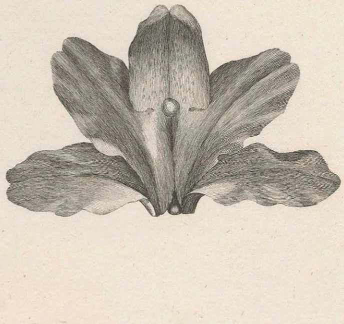
4. *The Calyx magnified.*



6. *Back View of the Corolla.*



5. *Front View of the Corolla,*
A globule of Honey in the center of the petal.

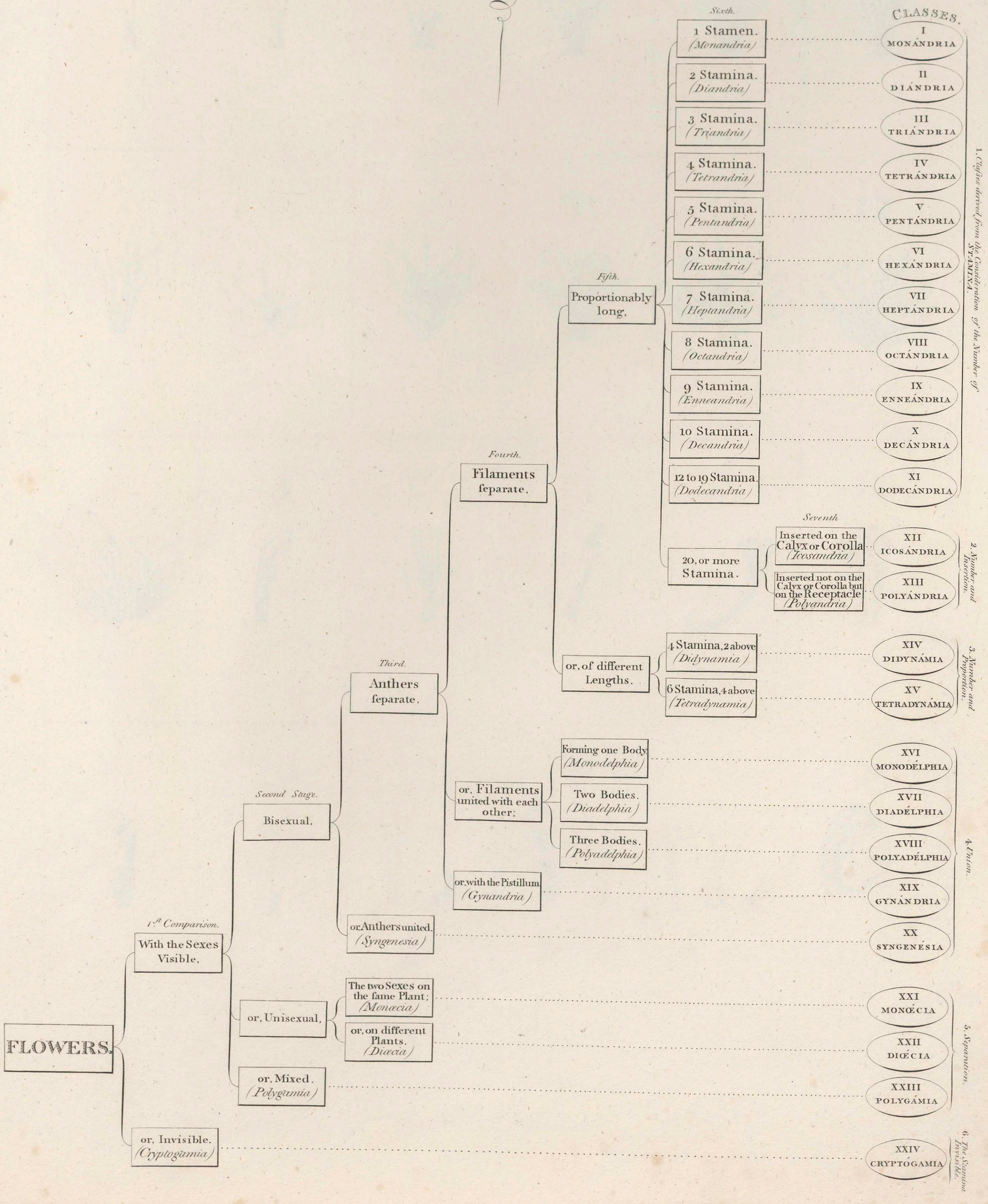


Anatomy of the Pontic Rhododendron.

Henderson del.

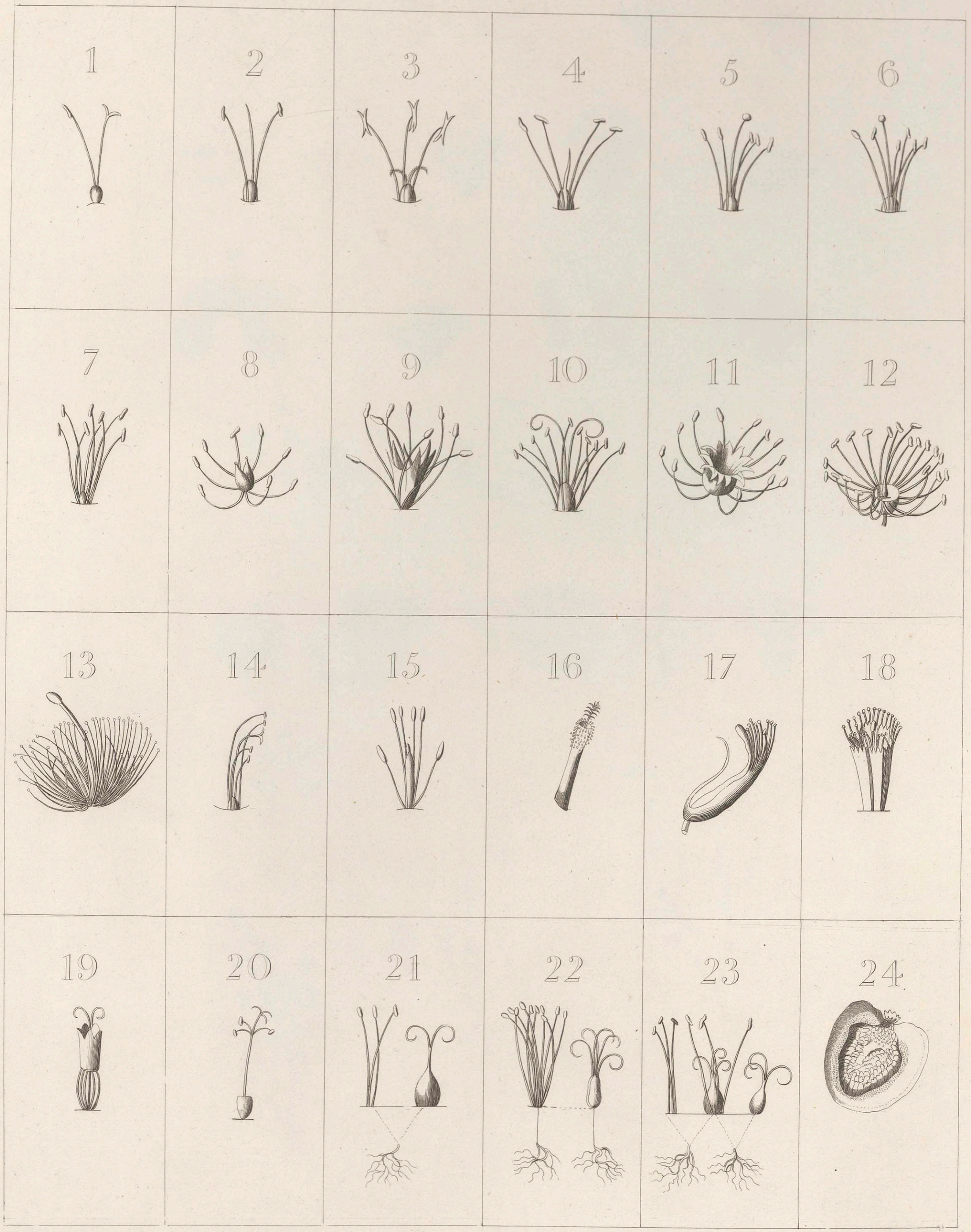
London, Published by Dr. Thornton, March 1, 1803.

ANALYSIS OF THE Sexual System.


FLOWERS.
1.st Comparison.
With the Sexes Visible,
or, Invisible. (Cryptogamia)
Second Stage.
Bisexual,
or, Unisexual,
or, Mixed. (Polygamia)
Third.
Anthers ſeparate,
or, Anthers united. (Syngenesia)
The two Sexes on the ſame Plant; (Monœcia)
or, on different Plants. (Diœcia)
Fourth.
Filaments ſeparate,
or, Filaments united with each other;
or, with the Pistillum (Gynandria)
Forming one Body (Monodelphia)
Two Bodies. (Diadelphia)
Three Bodies. (Polyadelphia)
Fifth.
Proportionably long,
or, of different Lengths.
4 Stamina, 2 above (Didynamia)
6 Stamina, 4 above (Tetradynamia)
Sixth.
1 Stamen. (Monandria)
2 Stamina. (Diandria)
3 Stamina. (Triandria)
4 Stamina. (Tetrandria)
5 Stamina. (Pentandria)
6 Stamina. (Hexandria)
7 Stamina. (Heptandria)
8 Stamina. (Octandria)
9 Stamina. (Enneandria)
10 Stamina. (Decandria)
12 to 19 Stamina. (Dodecandria)
20, or more Stamina.
Seventh
Inserted on the Calyx or Corolla (Icosandria)
Inserted not on the Calyx or Corolla but on the Receptacle (Polyandria)
CLASSES.
I MONÁNDRIA
II DIÁNDRIA
III TRIÁNDRIA
IV TETRÁNDRIA
V PENTÁNDRIA
VI HEXÁNDRIA
VII HEPTÁNDRIA
VIII OCTÁNDRIA
IX ENNEÁNDRIA
X DECÁNDRIA
XI DODECÁNDRIA
XII ICOSÁNDRIA
XIII POLYÁNDRIA
XIV DIDYNÁMIA
XV TETRADYNÁMIA
XVI MONODÉLPHIA
XVII DIADÉLPHIA
XVIII POLYADÉLPHIA
XIX GYNÁNDRIA
XX SYNGENÉSIA
XXI MONŒCIA
XXII DIŒCIA
XXIII POLYGÁMIA
XXIV CRYPTÓGAMIA
1. Claſses derived from the Conſideration of the Number of STAMINA.
2. Number and Insertion.
3. Number and Proportion.
4. Union.
5. Separation.
6. The Stamina Invisible.

The Sexual System

(As illustrated by Linnæus in his Botanical Works.)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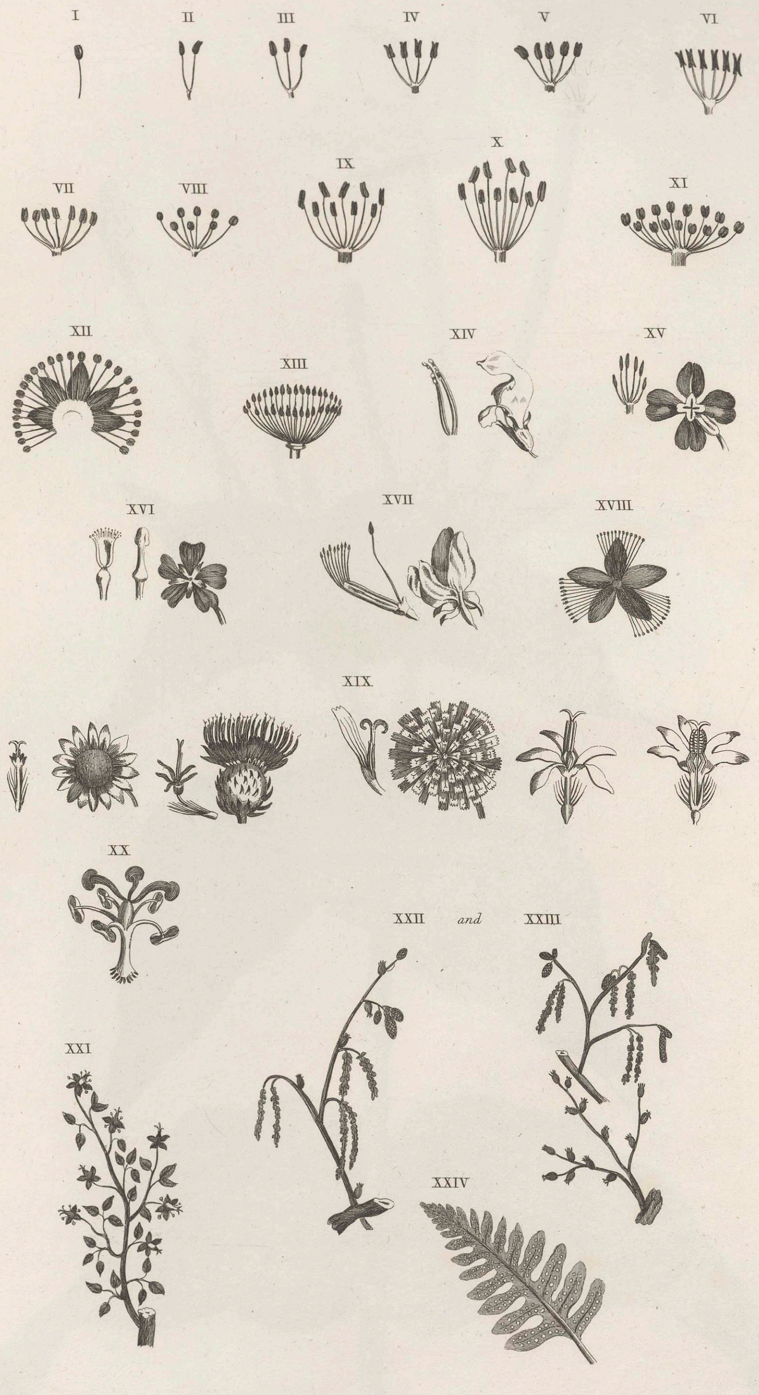
London. Published by Dr. Thornton Jany. 1st. 1805.

The Sexual System, as represented by modern Authors

CLASSES.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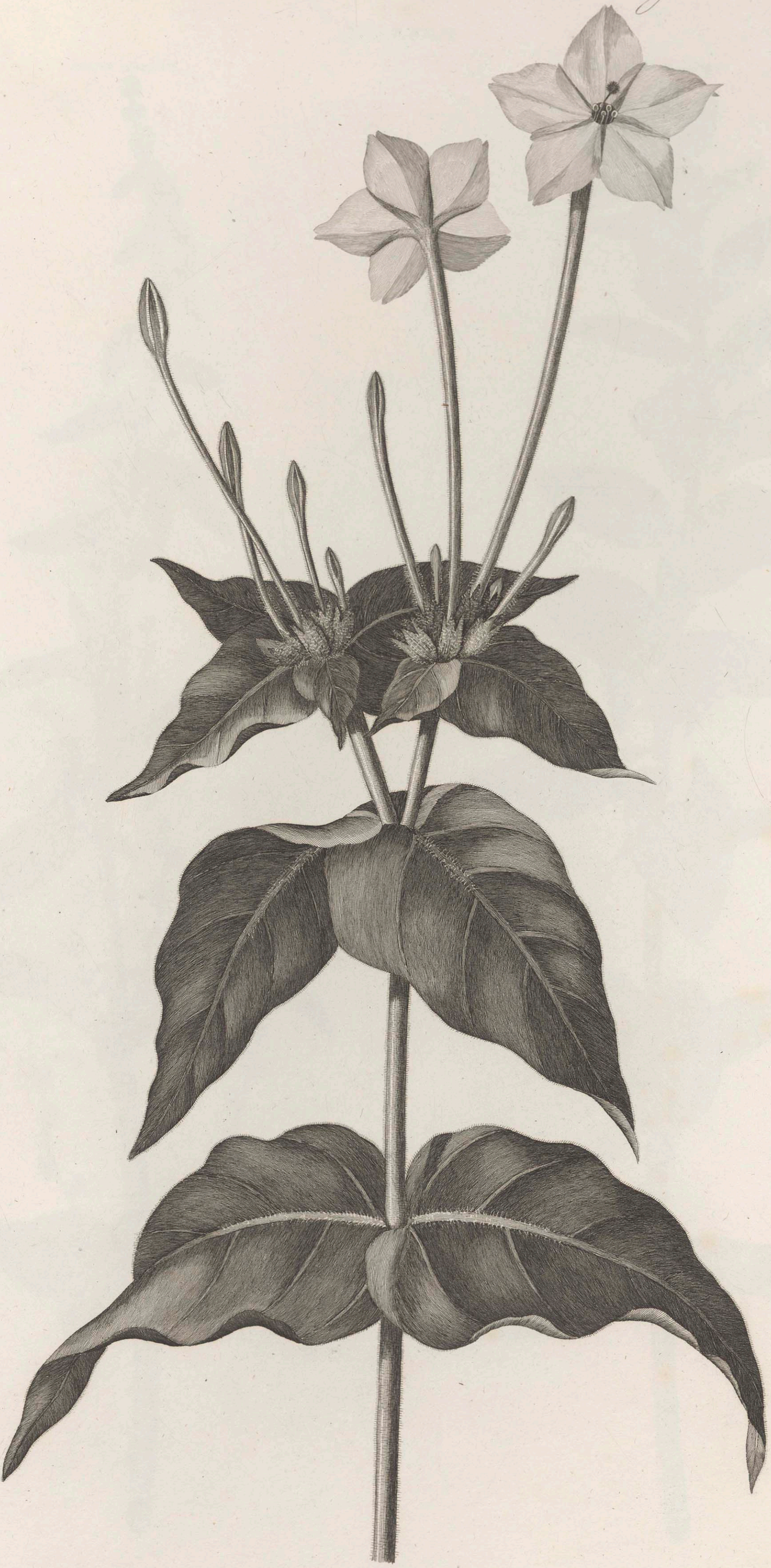
XX
XXII and XXIII
XXI
XXIV

Curtis, Author of the Flora Londinensis del.

Mazel sculp.

London, Published by Dr. Thornton, July 1. 1805.

A Plate to illustrate the Word Genus

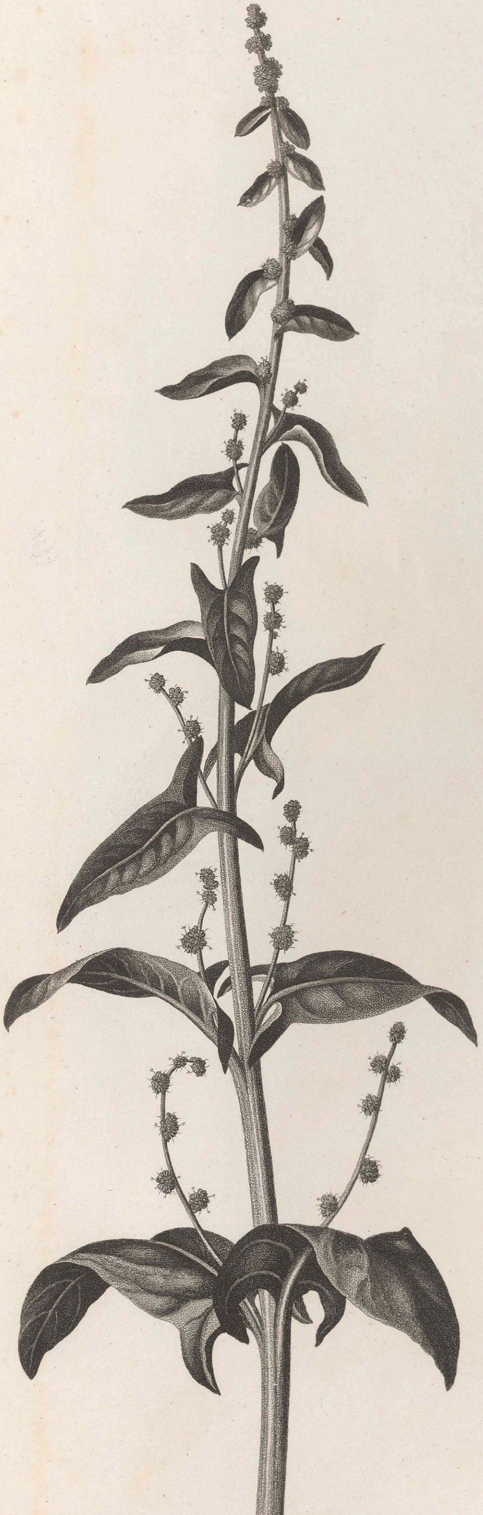


Long-tubed Marvel of Peru

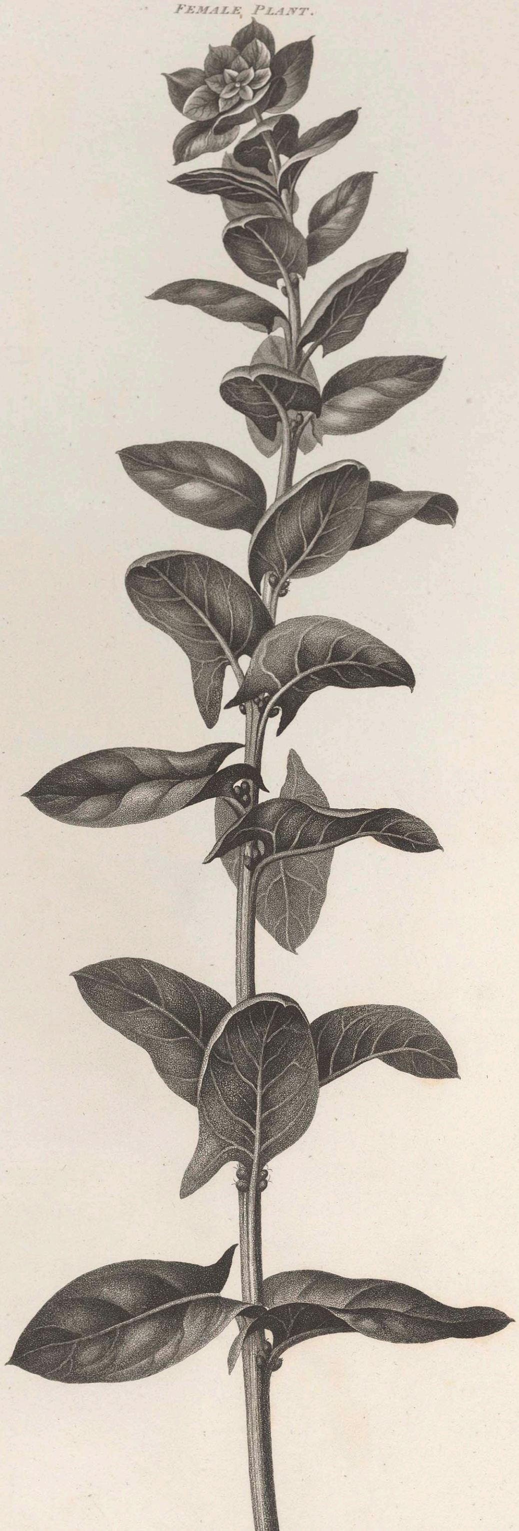
The Two Sexes on different Plants.

SPINACH.

MALE PLANT.



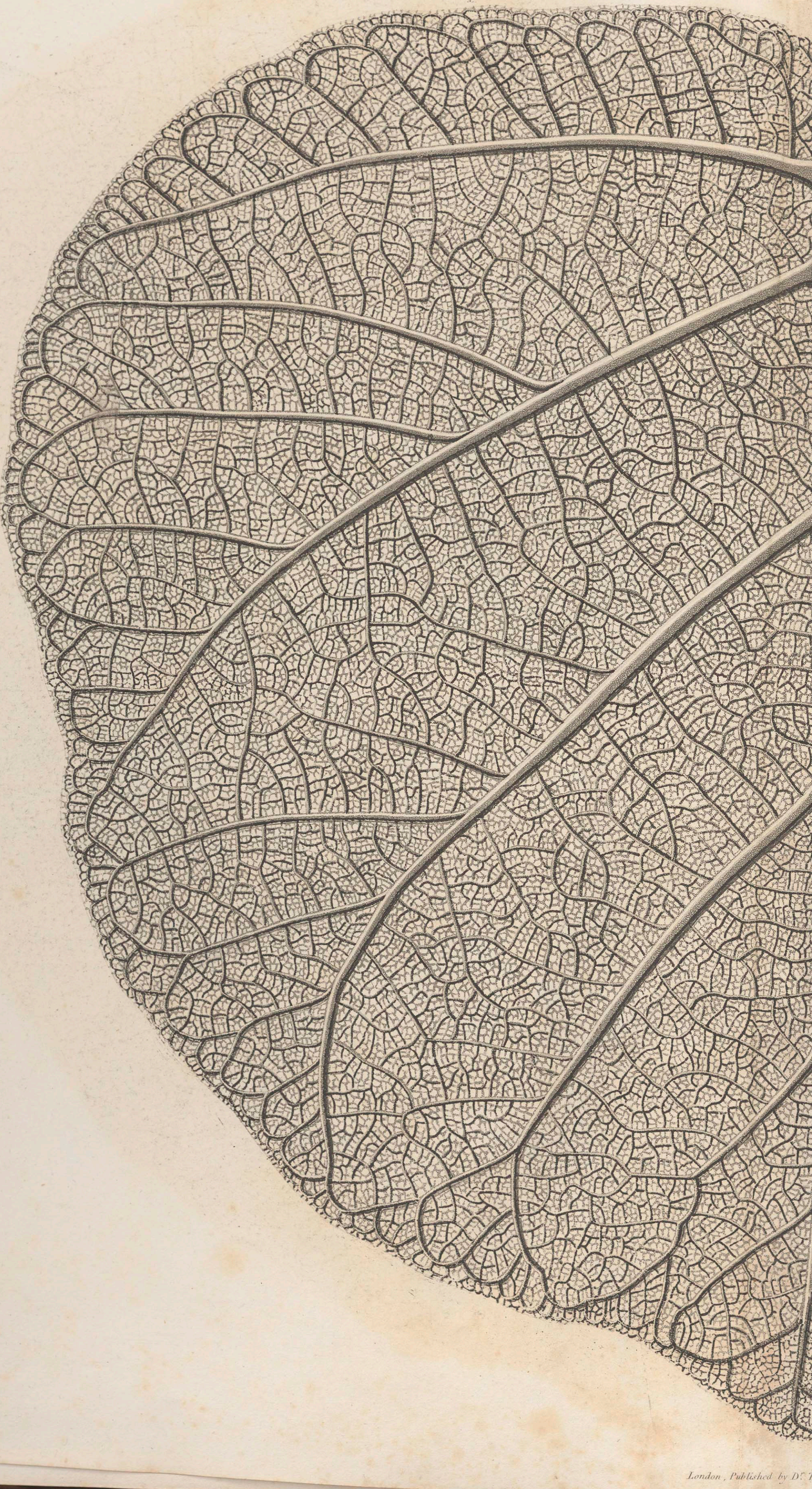
FEMALE PLANT.



Henderson pinx.

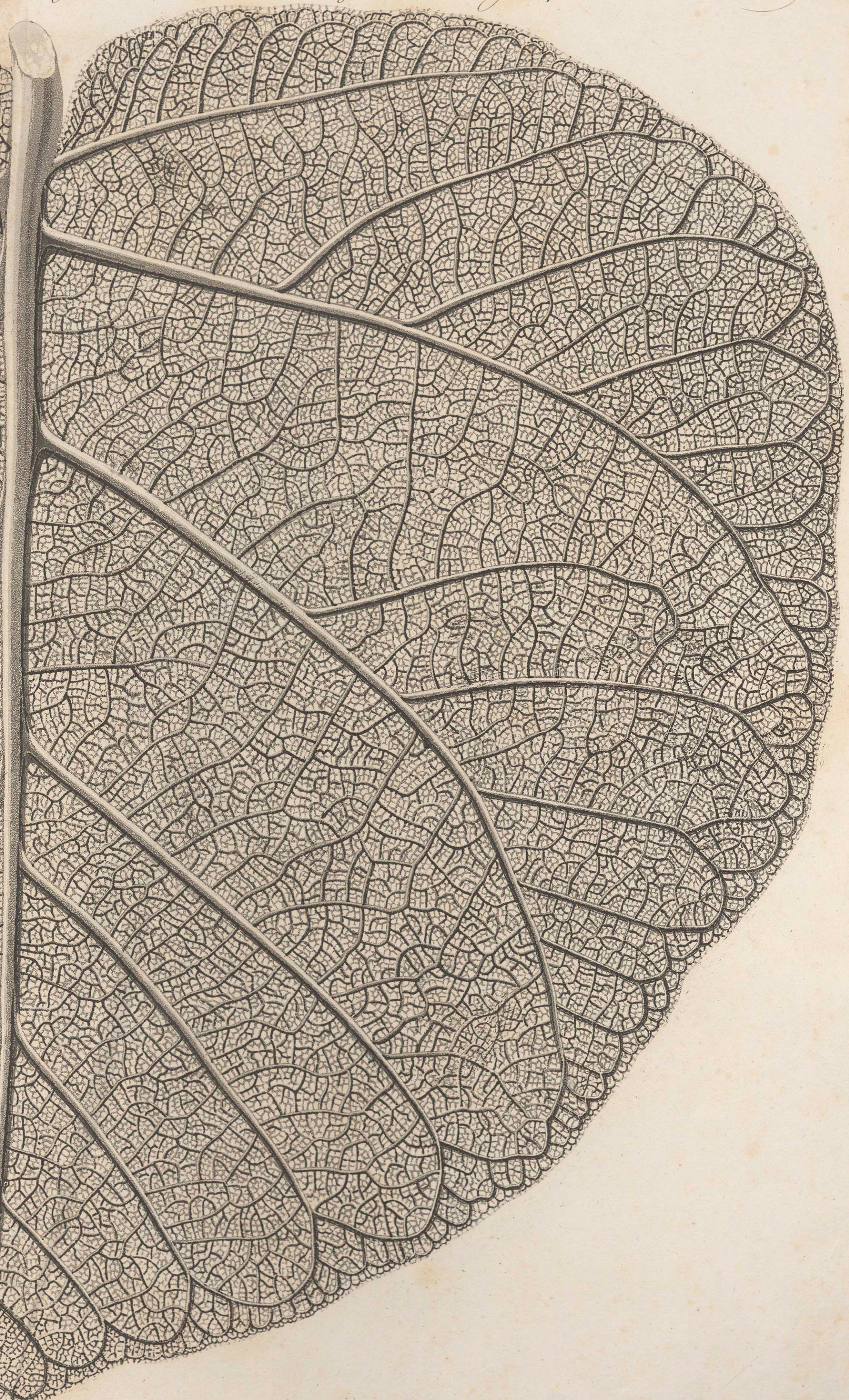
Caldwall sc.

The Skeleton of the Leaf of the Cocco



London, Published by Dr.

loba grandifolia, or large-leaf Grape-tree



Lewis del. et sculp.

ornton, Feb.y 1.st 1805.

TENAX IN FIDE

SAMUEL GEORGE SMITH.